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(54)【発明の名称】　インク・ジエツト・プリント・ヘツド

【特許請求の範囲】

【請求項１】インク供給源からインクを受け、各ノズルに結合した各インク駆動手段に応答してプリント媒体に向かってインク滴を噴射するマルチ・ノズルのドロップ・オン・デマンド型インク・ジェット・プリント・ヘッドであって、

互いに保持され、上記インク・ジェット・プリント・ヘッドを形成する複数の板を具え、

該複数の板の内の第１の板はインク噴射のためにインク滴が通過する１列になった複数のノズルを少なくとも有し、

上記複数の板の内の第２の板に複数の略円形のインク圧力室が形成され、該インク圧力室の各々の幾何学的中心が少なくとも３つの交差しない列の１つの上になるように上記インク圧力室は配置され、上記１つの列の上の上

記インク圧力室の幾何学的中心は隣接した他の列の上の上記インク圧力室の幾何学的中心とずれており、上記インク圧力室の各々はインク供給チャンネルに接続されたインク入口と通路に接続されたインク出口とを有し、上記インク入口及び上記インク出口が上記インク圧力室の両側に互いに分離しており、上記インク供給チャンネルからインクを吸い込んでこのインクを上記通路を介して上記第１の板の関連したノズルの１つに送り、

少なくとも１個の通路板が上記第１の板及び上記第２の板をより分離し、上記通路板は上記ノズルの各々を上記インク出口の関連する１個に夫々接続する略等しい長さ及び断面領域の複数の通路を有し、

上記複数の板の内の第３の板は上記第２の板に隣接して配置されると共に上記インク圧力室の各々と結合した上記インク駆動手段を有し、

上記ノズルの各々は類似の共振特性を有し、上記ノズルの各々に関連した上記インク駆動手段がほぼ同じ波形により駆動された際に上記ノズルの各々は略同じ噴射特性を有することを特徴とするインク・ジェット・プリント・ヘッド。

【発明の詳細な説明】

［産業上の利用分野］

本発明は、プリンタ用のヘッド、特に各々別々に駆動される複数のインク・ジェット・ノズルをアレイ状に構成した小型のインク・ジェット・プリント・ヘッドに関する。

［従来技術及び発明が解決しようとする課題］

インク・ジェット・システム特にドロップ・オン・デマンド型又はインパルス型インク・ジェット・システムは従来より周知である。インパルス型インク・ジェット装置の原理は、インク室を変位させノズルを介してインク室からインク滴を射出することである。インク室を変位させるために駆動機構が使用される。典型的な駆動機構は、薄い隔壁に結合した圧電素子の如き変換器を含んでいる。この変換器に電圧を印加すると、変換器は平面の大きさを変化させようとするが、隔壁にしっかりと結合しているので折り曲がる結果となる。この変換器の折り曲がりによりインク室内のインクが変位し、インク供給口からインク室にインクが流れ込むと共に出力口からノズルへとインクが送られる。一般に、多数のノズルを高密度のアレイ状に配列出来るようにヘッドを構成することが望ましい。しかし、多数のインク室を設け、これらのインク室に対応する多数のノズルを接続することは、それほど簡単に出来ることではない。これは、特にアレイ状の小型インク・ジェット・プリント・ヘッドの場合には大きな問題である。これに関連していくつかの従来例を挙げる。

ジュリアナ・ジュニア等の米国特許第4266232号及びドーリングの米国特許第4312010号では、複数のインク圧力室から延びる複数のチャネルを夫々ノズルに集約させ、より狭いセクションにノズルの間隔を狭くした高密度のノズル・アレイを実現している。このような狭くしたセクションに高密度にノズルを実装すると、プリント・ヘッドの厚さが格段に増し、製造工程が複雑になってしまう。更に、ドーリングの特許では、インク室に夫々対応するノズルを接続するための異なる長さのチャネルを設けたノズル・アレイを開示している。この種のヘッドは、長さの異なる多数のチャネルを設けるので、ノズルによってインク噴射特性が変化してしまう。高価につく駆動回路を設けて長さの異なるチャネルに対する補正をするように圧電変換器を制御することも可能であるが、仮えそのような駆動回路を設けたとしても、種々の特性を有するノズルから一様なインク滴を噴射させることは困難である。

ステムの米国特許第3747120号明細書の第20図には、別

のインク・ジェット・プリント・ヘッドの例が開示されている。この設計例では、２列、３列及び２列の円形インク圧力室を夫々中心をずらして配置している。夫々のインク圧力室は異なる長さのチャネルで共通のインク室に夫々接続されている。ノズルは、この共通インク室に夫々接続されている。このように、ノズル群とチャネル群の間に共通インク室を設けた場合の欠点は、個々のノズル間に音響的クロストークが発生することである。

ドーリング等の米国特許第4599628号では、ノズル・アレイを有する更に別構造のインク・ジェット・プリント・ヘッドを開示している。この例では、略円錐形のインク圧力室により夫々のノズルが共通のインク供給装置に接続されている。これらのインク圧力室は各々が円形の断面を有する２列の互いに平行な圧力室群に形成されており、一方の列のインク圧力室群の中心と他方の列の圧力室群の中心が夫々一直線に並べられている。

クルツ・ウリベ等の米国特許第4680595号には、別構成のインク・ジェット・プリント・ヘッドが開示されている。この公報の第１図、第３図、第５図及び第６図は、略長方形のインク圧力室群を２列の平行な群に分け、それらの中心を位置合わせした装置を示している。インク・ジェット・ノズルは各々対応するインク圧力室に接続されている。各ノズルの中心軸は、インク圧力室を含む面に垂直に延びており、インク圧力室の延長部分と交差している。また、ノズル孔と夫々位置が整合するように注意深く形成されたインク孔を介してインクがこれらの圧力室に供給される。一般に、特定の粘性を有するインクを用い、所定のインク滴噴射率で且つ同じ駆動電圧で動作させる場合、長方形の圧電変換器の方が丸型又は六角形型の場合よりも表面積が大きくなる。更に、この従来のインク・ジェット・アレイの構造では、ある大きさのインク・ジェットにインク室を組み込む場合に大きさの制限が生じる。

カナヤマの米国特許第4460906号は、円形のインク圧力室とノズルとを接続するオフセット・チャネルを設けたインク・ジェット・プリント・ヘッドを開示している。このプリント・ヘッドでは、インク圧力室の面に垂直な方向にインクが噴射されるので、インクを噴射する各ノズル外側表面にインク溜まりが生じてしまう。この結果、対応するインク圧力室から供給されるインク以外のインクがノズルに供給されるので、上述のステムの特許の場合と同様の問題が生じる。

マツダ等の米国特許第4216477号及びコトの米国特許第4525728号の内容は、インク圧力室の面に対して垂直ではなく平行にインクを噴射させるインク・ジェット装置の代表的な例である。一般に、インク圧力室の面に平行にインクを噴射させる従来の装置は、比較的製造が複雑になるという欠点がある。コトの特許の例では、一列の長方形変換器群を基板の一方の側面に設け、他の一列の変換器群を基板の反対の側面に設けている。この基板の一

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方の側面の変換器群とそれに対応するノズルの開口部は、反対の側面の変換器群とノズルの開口部に対して位置がずれているので、高密度実装に不利である。マツダ等の特許の例では、各長方形の変換器は、通路を介してノズル孔に接続されたインク室に結合されている。この特許明細書に記載された実施例の場合、ノズル孔に接続されたインク通路の長さは、各変換器とそれに対応するノズルとの位置関係に応じて異なっている。フィッシュベック等の米国特許第4584590号の第３図及び第４図には、長方形の変換器の面に平行な方向にインク滴を射出し、且つインク室の体積を伸縮する別の形式のインク・ジェット・プリント・ヘッドが開示されている。インク圧力室の面に平行なインク滴を射出する別の例は、ツヅキの米国特許第4435721号、マツダの米国特許第4528575号、カムラの米国特許第4521788号及びヤマムロの米国特許第3427850号に開示されている。

このように、インク・ジェット・プリント・ヘッドに関しては多くの従来例があるが、これらの従来例と比較して、更に小型で、製造が容易で、高速動作が可能で、且つ効率の高いインク・ジェット・プリント・ヘッドを実現することが重要である。

従って、本発明の目的は、複数のノズルを接近させてアレイ状に構成した小型のインク・ジェット・プリント・ヘッドを提供することである。

本発明の別の目的は、製造が比較的容易で製造コストを低減したインク・ジェット・プリント・ヘッドを提供することである。

本発明の他の目的は、比較的高速に効率よく且つ安定的に動作し得るインク・ジェット・プリント・ヘッドを提供することである。

本発明の更に他の目的は、個々のノズルのインク滴射出特性が略同一であるインク・ジェット・プリント・ヘッドを提供することである。

［課題を解決する為の手段］

本発明のインク・ジェット・プリント・ヘッドは、多層板構造を有し、これらの多層板は、インク滴を射出する為の複数のノズルを形成したノズル板と、略円形の複数のインク圧力室を互いに接近させ少なくとも２列に配列形成した圧力室板と、上記ノズルとそれに対応する上記インク圧力室の出力口とを夫々接続する通路を形成したインク通路板と、上記第２の板に接合され、上記複数のインク圧力室と駆動手段を隔てる隔壁板とを具えており、圧力室板の１つの列内の各インク圧力室の中心位置に対して隣合う列内の各インク圧力室の中心位置を列方向にずらして配置している。

［作用］

本発明のインク・ジェット・プリント・ヘッドは、装置全体の大きさに影響する複数のインク圧力板の配列を効率的に配置することにより、小型で製造が比較的容易な装置を実現している。

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［実施例］

先ず、本発明の実施例の説明の前に前提となる技術に関して説明する。本発明の契機は、圧電変換器の如き駆動機構により各々が駆動される複数のインク・ジェット・ノズルをアレイ状に構成した小型のドロップ・オン・デマンド・インク・ジェット・プリント・ヘッドへの要請である。プリント・ヘッドが両方向に反復移動しプリントを行い、その後プリント媒体が曲面上を垂直方向に送り出されるようなタイプライタ型のプリント装置に使用されるインク・ジェット・プリント・ヘッドを考えてみよう。この場合、ノズル・アレイの垂直方向の長さを出来る限り小さく形成して種々のノズルからプリント媒体までの距離のばらつきが出来るだけ小さくするようなプリント・ヘッドが望ましい。この最小な垂直距離は、プリント線密度の逆数と特定のカラーをプリントするジェット・ノズルの数との積に等しい。例えば、黒色をプリントする48個のノズルで１インチ当たり300ラインの密度でプリントをする場合、そのノズル列の最小垂直距離は、47/300インチとなる。

更に、プリント・ヘッドの水平方向の長さも最小にすることが望ましい。原理的には、48個のノズルを用いて１インチ当たり300ラインを黒色で水平及び垂直方向にプリントするヘッド部分の場合、48個のノズルの垂直方向の列は最初のノズルの中心から最後のノズルの中心までの長さが47/300インチとなる。この構成の場合、各ノズルは、余分な走査動作をすることなく、紙（プリント媒体）の右端から左端までプリントすることが出来る。ノズルを水平方向にずらして構成すると、プリント媒体上の全ての領域にプリントする為には、少なくともそのずらした長さだけ走査動作のマージンを取って水平方向に余分に走査する必要がある。このような余分な走査動作により、プリント時間も長くなる上にプリンタ装置全体の幅も大きくなってしまう。従って、装置の幅を小さくするには、ノズルの水平方向の間隔を最小にすることが望ましい。圧力変換器（圧電変換器とインク圧力室内に曲がる隔壁の組み合わせ）の横方向の寸法は、プリント線密度の逆数の値より何倍も大きくなければならないので、ノズル群をある程度水平方向にずらして配置する必要がある。このずらす長さは、変換器の寸法及びノズルの配置によって決まる。よって、このずらす長さを最小にするのが良い。

ノズルの水平方向の間隔を最小にする一つの方法は、インク圧力室又は圧力変換器のアレイの境界内に何も構成要素を入れないことである。他の全ての構成要素は、これら圧力室又は変換器と同じ面内にある場合には、そのアレイの外側に配置するか、或いはそのアレイの上（ノズル群より更に上の位置）又は下（ノズル群に近い位置）に配置する。例えば、変換器への電気的接続は全て圧力変換器の上側の面内に設けることが出来、他方、入口通路、オフセット、チャネル通路、出力口通路及びノ

ズル群は全てインク圧力室又は圧力変換器の下側の面内に設けることが出来る。これらの中の２種類の要素を同じ面内に設けたら、互いに邪魔になるので、互いに異なる面内に配置する。その結果、ノズル群の水平方向のずれは、複数の圧力変換器又はインク圧力室をどれだけ接近させて配置出来るかということのみによって決まる。例えば、入口通路はオフセット・チャネル通路とは違う面内に配置することが出来、オフセット・チャネル通路は出口通路と異なる面内に配置可能である。従って、ノズル・アレイの垂直及び水平方向の寸法を最小にする為には、プリント・ヘッドの厚さを増して、多層構造にすれば良い。

IC構成の電子駆動回路は、一般に個々の部品から回路を組む場合より安価である。このIC内の全ての駆動回路を同じ瞬間にトリガすることが出来れば、もっと安価になる。よって、プリント・ヘッドのノズル群を垂直方向に一列に配置出来ない場合、１つのノズルと隣のノズルとの水平方向のずれは、安価な駆動回路を用いれば、水平方向のプリント線密度の逆数の整数倍となる。２つ以上の駆動回路を使用した場合、この要件は緩和されるが、１つのICで駆動される全てのノズル群の水平方向の間隔は、水平方向のプリント線密度の逆数の整数倍になる。また、駆動電圧を低電圧とし、高速にインク滴を噴射する動作が可能で、比較的組立が容易であり、多色のインクをプリント出来る小型のプリント・ヘッドを実現することが望ましい。一般に、これらの特徴を全て合わせ持つプリント・ヘッドが最も望ましい。もっとも、これらの各特徴は、どれも望ましいものであり、本発明のインク・ジェット・プリント・ヘッドの特徴として個々に寄与している。

第２図は、本発明のインク・ジェット・プリント・ヘッドの一実施例であり、ヘッド本体10にはインクが供給されるインク入口12が形成されている。ヘッド本体10には更にインク滴を形成する出力口、即ちノズル14及びインク入口12からノズル14までのインク流経路が形成されている。一般に、本発明のプリント・ヘッドは、多数のノズルで構成されたノズル・アレイ14を含み、これらのノズルは互いに接近して配置されており、各ノズルから噴射するインク滴によりプリント媒体（図示せず）にプリントする。

インク入口12に入ったインクは、インク供給多岐管16に流れ込む。典型的なインク・ジェット・プリント・ヘッドは、黒色、シアン、マゼンタ及びイエローを夫々受ける少なくとも４つの多岐管を有し、これらは黒色及び減法三原色のプリントに用いられる。しかし、多岐管の数は、プリンタの設計、例えば黒色のみでプリントするとか、フルカラーより少ない色でプリントするとかの場合に応じて変更し得る。インク供給多岐管16からインクはインク供給チャネル18及びインク入口20を通過してインク圧力室22に流れ込む。インクはインク圧力室22から出口24を介して流れ出て、インク通路26を通ってインク滴が射出するノズル14へ供給される。矢線28はインクの流れを示している。

インク圧力室22は、可撓性の隔壁34により一方の側面が形成されている。この例の圧力変換器は隔壁34にエポキシ樹脂により固着された圧電セラミック・ディスク36であり、インク圧力室22に張り付けられている。従来と同様に、圧電セラミック・ディスク36は、図示していないが電子駆動回路に電気的に接続された金属膜層38を有する。他の構成の圧力変換器を用いても良いが、第２図の圧力変換器は折り曲げモードで動作する。即ち、圧電セラミック・ディスクに電圧が印加されると、ディスクが大きさを変えようとする。しかし、ディスクは隔壁にしっかりと固着されているので、折り曲がる結果となる。この折り曲がりによりインク圧力室22内のインクに変位が生じ、通路26を通ってインクが外向きに流れノズル14へ供給される。インク滴の射出後、インク圧力室22へのインクの再注入は、圧力変換器36が反対側に折れ曲がることにより行われる。

上述のインクの出力流経路に加えて、選択的インク出口、即ちパージ・チャネル42もヘッド本体10に形成されている。このパージ・チャネル42は、ノズル14に隣接するヘッドの内側部分にインク通路26と接続されている。このパージ・チャネル42によりインク通路25からパージ多岐管44が接続されており、このパージ多岐管44から出力通路46を介してパージ出力ポート48に接続している。このパージ多岐管44は、通常、パージ・チャネル42と同様のチャネルにより多数のノズルに対応するインク通路に接続されている。パージ動作（気泡等の除去動作）中に、矢線50で示すようにパージ・チャネル42から多岐管44及びパージ通路46へとインクが流れるが、詳細については後述する。

本発明のインク・ジェット・ヘッドの製造を容易にする為には、ステンレス鋼材等の多層板又は多層シートでヘッド本体10を形成するのが好適である。第２図の実施例では、これらの多層シート又は多層板は次のような種々の板で構成されている。隔壁板60は、隔壁34、インク入口12及びパージ出口48を形成している。インク圧力板62は、インク圧力室22、インク供給多岐管の一部分、及びパージ通路48の一部分を形成している。分離板64は、インク通路26の一部分、インク圧力室22の一方の境界面、インク圧力室の入口20及び出口24、インク供給多岐管16の一部分、並びにパージ通路46の一部分を形成している。インク入口板66は、インク通路26の一部分、入口チャネル18及びパージ通路46の一部分を形成している。また別の分離板68は、インク通路26及び46の一部分を形成している。オフセット・チャネル板70は、通路26の主要部（オフセット・チャネル部分）71及びパージ多岐管44の一部分を形成している。分離板72は、通路26及びパージ多岐管44の一部分を形成している。出口板74は、パー

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ジ・チャネル42及びパージ多岐管44の一部分を形成している。ノズル板76は、アレイ状のノズル14を形成している。選択的ガード板78は、ノズル板76を保護し、ノズル板がスクラッチや他の損傷を受ける可能性を防止する。図示した実施例よりも多くの又は少ない数の金属板を用いて種々のインク通路、多岐管及びインク圧力室を形成して本発明のインク・ジェット・プリント・ヘッドを実現しても良い。例えば、第２図のように１枚の板でインク圧力室22を形成する代わりに多数の板を用いても良い。また、多層金属板に種々の機構の全てを形成する必要もない。例えば、化学的エッチング処理により製造するとした場合、金属の化学的エッチングの為のテンプレートとして使用するホトレジスト・パターンは、金属板の各面毎に異なっていても良い。従って、より具体的な例を挙げれば、インク入口通路のパターンを金属シートの一方の面上に施し、その他方の面上には圧力室のパターンを施すようにしても良い。よって、エッチングを注意深く制御することにより、別々のインク入口通路及びインク圧力室を共通の金属層に組み込むことが可能である。

組立コストを最少にするには、ノズル板76を除くインク・ジェット・プリント・ヘッドの全ての金属層を従来の比較的安価なホトパターン工程及びエッチング工程を用いて製造出来るように設計を行う。機械加工工程又は他の金属加工工程は必要でない。ノズル板76は、以下のような種々の工程を経て完成したものである。即ち、含硫黄ニッケル漕からの電気鋳造、300シリーズ・ステンレス鋼材の微小放電加工、及び300シリーズ・ステンレス鋼材の穴開け等である。最後の２つの処理は、ノズル板のノズルを除く全ての機構のホトパターン処理及びエッチング処理に関連して用いられる。別の適当な処理は、ノズルの孔を開けること及び標準の圧断処理によりこの板の残りの機構を形成することである。本発明のプリント・ヘッドは、金属層間の位置合わせの条件が厳しくならないように設計される。即ち、化学的エッチング処理で維持可能な通常の許容範囲が適切なのである。

本発明のインク・ジェット・プリント・ヘッドを形成する種々の多層金属層は、適当な機械的締め付け器を用いるような何らかの適当な方法で位置合わせ及び結合される。金属層間の結合に適切な方法は、アンダーソン等の米国特許第4883219号（特願平１－226369号に対応）に記載されている。この明細書に記載された方法によれば、種々の金属層を金属で1/8～1/4μmの厚さにメッキする。このメッキする金属は金属層と良好に拡散結合し、且つろう付けに適したものであり、ヘッドのステンレス鋼材上に信頼性の高いメッキが可能であり、ステンレス鋼材を使用しない場合でもそのヘッドを形成する金属に良好にメッキし得るものである。例えば、金は、ステンレス上に容易にメッキ出来る上に極めて良好に結合及びろう付けすることが可能である。メッキ処理の後、

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種々の金属層を簡単な２本ピンのアラインメント装置上に順番に積み上げる。このアラインメント装置は拡散結合装置としても機能する。これら積み上げた部品に以下の処理を行う。

（ａ）種々の金属層の熱歪を最小にする温度範囲、即ち400～500℃で拡散結合させる。

（ｂ）拡散結合装置から金属層部品を取り外す。

（ｃ）水素雰囲気中のろう付け炉の中に固定しないで挿入する。

（ｄ）ろう付けする。

この結合過程は、密閉状態で行われ、部品間の結合力は強く、プリント・ヘッドの微小なチャネルを塞いでしまうような突起部を残すことがなく、プリント・ヘッドの各部の機構を歪ませることがなく、極めて高い満足度、略100パーセントに近い優れたプリント・ヘッドを実現出来る。この製造工程は、標準のメッキ装置、標準のろう付け炉、及び簡単な拡散結合装置を用いて実行可能であり、多くのインク・ジェット・プリント・ヘッドを製造しつつ、結合工程の最初から最後まで３時間以内で完了することが出来る。更に、メッキした金属は非常に薄いので、ろう付け工程の際にメッキした金属層の殆ど全てがステンレス鋼の中に拡散するので、この金属がインクに化学的変化や電気分解等の作用を与えることはない。従って、メッキ金属としてインクと容易に反応するような例えば銅の如き金属を結合工程で使用しても問題はない。

本発明のインク・ジェット・プリント・ヘッド用に選択した電気機械的な圧力変換機構34及び36は、金属化させた複数の圧電セラミック・ディスクを含み、第１図に示すように、これら圧電セラミック・ディスクは夫々対応するインク圧力室22の上に中心を合わせてエポキシ樹脂で金属隔壁板60に固着されている。第１図は、16個のジェット・ノズルを有するノズル・アレイ型プリント・ヘッドの組立に用いられる種々の金属層60～78の分解斜視図である。この型の変換器は略円形にすると最も電気機械的効率が高くなる。この電気機械的効率は、圧電セラミック素子の所定の領域の体積変位に関連している。従って、この型の変換器の方が、折れ曲がりモードで動作する矩形型のものよりも効率が高い。

非常に小型のインク・ジェット・プリント・ヘッドを容易に製造する為に、第１図に示すように、種々のインク圧力室22は、略平坦になっている。即ち、圧力室22はその深さに比べ横断面の方が遥かに大きいので、圧力室の体積の変位により高圧が発生する。更に、本発明のプリント・ヘッドのインク圧力室の全てが、インク・ジェット・プリント・ヘッド内の同じ平面又は同じ深さの位置に好適に配置されている。但し、これは必須要件ではない。この圧力室の位置は、第２図及び第１図に示すように、１枚以上の金属板62の面で決まる。

高密度にヘッドを形成する為に、インク圧力室22は、互

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いに幾何学的中心をずらした少なくとも２列の領域を平行に配置している。また、これら圧力室は、極めて僅かなシート状材料により互いに分離されている。一般に、圧力室の間にはこのシート状材料が残っているが、これは金属層間でインクの漏れが起こらないように金属層間の結合の信頼性を高める為である。第１図～第７図（第３図は第１図の種々の層に亘る構成を平面的に示し、第４及び第５図は本発明の第２実施例を示し、第６図は本発明の第３実施例を示し、第７図は各部分を重ねて示した図である）に示すように、好適実施例は少なくとも４つの平行なインク圧力室22の列を含んでおり、これらの列の中心は隣の列の中心からずれた位置にある。特に、第１図の円形圧力室では、４つの平行な圧力室の列の位置をずらしてあり、各圧力室の中心を直線で結ぶと六角形のアレイを形成するようになっている。圧力室の中心は、不等辺六角形の配列状に位置しているが、最も小型な構造にするには正六角形状に配列すれば良い。この配列はどちらの方向に任意に拡張してインク・ジェット・プリント・ヘッドに設ける圧力室及びノズルの数を増加しても良い。一般に、効率良く動作させる為には、圧力室の横断面の方向に略等方的な大きさを有するのが望ましい。従って、略円形の圧力室が極めて効率的であると考えられる。しかし、例えば横断面が六角形にした他の構造の圧力室も実質的に横断面について等方的であり、効率的であると考えられる。他の構造の圧力室も採用し得るが、横断面について略等方的なものが望ましい。

圧電セラミック・ディスク36の代表的な厚さは、0.010インチであるが、それより薄くても厚くても良い。これらのディスクは、円形のインク圧力室に合わせて略円形にするのが理想であるが、これらのディスクを六角形に形成すると、僅かであるが必要な駆動電圧が上昇する。従って、これらディスクは大きな母材から例えば丸鋸等で切り取って作ることができる。これら六角形の圧電セラミック・ディスク36の内接円の直径は、通常、対応する圧力室22の直径より数千分の１インチだけ小さく、これらのディスクの外接円の直径は数千分の１インチだけ大きくなっている。隔壁層60の代表的な厚さは、0.004インチである。

第２図に関して説明したように、インク通路26により各圧力室が対応するノズルに接続されている。一般に、これらの各通路26は、対応する圧力室22に垂直方向に第１距離だけ延びた第１セクション100、圧力室22の面に平行な第２方向に第２距離だけ延びた第２（オフセット・チャネル）セクション71、及び第２方向に垂直で対応するノズルの方向に延びた第３セクション104で構成されている。通路26のオフセット・チャネル・セクション71により、対応するインク圧力室間の中心間隔よりノズル間の中心間隔を狭くするように複数の列のノズル14の位置が決められる。

オフセット・チャネル・セクション71は通路26の主要部

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である。更に、通路26及び特にオフセット・チャネル・セクションは、インク圧力室22とそれらに対応するノズルの間に配置されている。圧力室及びノズルに対応する通路26は、長さ及び断面の大きさが等しいことが望ましい。従って、圧力室の入口チャネルが長さ及び断面の大きさが同じであると仮定すると、各ジェット機構の全てが同じ共振特性を有し、同じ波形で駆動することにより種々のノズルから略同じインク滴噴射特性でプリントすることが可能になる。更に、オフセット・チャネル・セクション71は、通常、単一の共通金属板に形成されているので、インク・ジェット・プリント・ヘッドの厚さひいては重さ及びコストを最少にすることが出来る。第１図～第８図及び第15図（第８図は本発明の第４実施例を示し、第15図はこの実施例の一部を示す）では、オフセット・チャネル・セクション71は、通路部分100及び104の間を接続している。六角形に配置した圧力室の中心間の間隔が、0.135インチならば、オフセット・チャネル・セクションの一端の中心から他端の中心までの距離は0.116インチである。即ち、正三角形の幾何学的性質からオフセット・チャネル・セクションの長さは、インク圧力室の中心間距離に

$$\sqrt{3}/2$$

を乗算したものに等しい。更に、オフセット・チャネル71は、ノズルの隣にある一端の幅が0.015インチであるが、他端の幅は0.024インチである。勿論、これらの値は変更可能である。例えば、このチャネルの他端の幅は、0.020～0.036インチの範囲で試験して良好な結果が得られた。オフセット・チャネルの代表的な厚さは、0.20インチであるが、この厚さは２枚の同じ層を重ねて形成しても良い。

再び、第１図～第３図を参照する。ノズル14は、金属番62の面及び対応するインク圧力室22の面に略垂直な中心軸を有する。更に、これらのノズルの中心軸は、金属番62に交差するまで延長すると、対応するインク圧力室に交差せずずれている。第１図及び第３図のインク・ジェット・プリント・ヘッドでは、ノズル14が１列に配置されている。これは直線的に配列するのが望まいしが、必ずしも直線的に配列する必要はない。他方、これらのノズルに接続されたインク圧力室22は、４列に配置されている。更に、圧力室の横の寸法は0.110インチでこれら圧力室22の六角形アレイは0.135インチ間隔で配列されている。従って、これらインク圧力室は、金属層の結合に必要な最少量だけの間隔で近接して設けられている。ノズルの直径は、35～85ミクロンの範囲が良好であったが、この範囲に必ずしも限られるものではない。水性インクで単位インチ当たり300ドットをプリントするには、プリント媒体のインク滴の拡散が制限されるので、ノズルの直径は、約75ミクロン程度にすることが望ましい。これらの例では、ノズル板の適当な厚さは、約63～

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75ミクロン、即ち0.0025～0.0030インチである。

更に、第１図及び第４図の構成上、特にオフセット・チャネルにおいては、動作中に於けるノズル間の中心間隔は、約0.0335インチである。この間隔の場合、ノズルの線が水平位置からアークタンジェント1/10の角度だけ回転した位置にあると（第８図参照）、隣合うノズル間の垂直距離は、丁度1/300インチとなり、対応する水平間隔は、10/300インチとなる。これらの水平及び垂直方向の間隔の場合、プリント・ヘッドは、水平及び垂直の両＊

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＊方向に単位インチ当たり300ドットの密度でプリントするように設定されている。

上述のインク圧力室及びノズルの構成を有するインク・ジェット・プリント・ヘッドを考えよう。また、垂直プリント密度の逆数をｖ、水平プリント密度の逆数をｈ、ノズル間の水平ドットの数をｎと仮定する。この場合、第７図を参照すると、ノズル間の間隔をｓ、圧力室間の中心間隔をＣ、圧力室の列の間隔をＬとすると、以下の関係式が成立する。

$$s = \sqrt{v^2 + (nh)^2}$$

$$C = 4s = 4\sqrt{v^2 + (nh)^2}$$

$$s = (\sqrt{3}/2)\,C = 2\sqrt{3}\sqrt{v^2 + (nh)^2}$$

更に具体的な例として、ｖ＝ｈ＝1/300インチとすると、以下の表に示すように、種々のｎの値に対してｓ、Ｃ及びＬの値が選択される。

［　　表　　］

n	s(インチ)	C(インチ)	L(インチ)
10	.0335	.1340	.1160
9	.0302	.1207	.1046
8	.0269	.1075	.0931
7	.0236	.0943	.0816
6	.0203	.0811	.0702

これ以外の値も同じように計算出来る。また、ノズル間の水平間隔の水平プリント密度の逆数の整数倍がいくつでも同じ計算を適用出来る。

第７図では、圧力室が４列あるが、圧力室22のインク入口20及びインク出口24が全く反対側に設けられている。ノズル14の１列だけがインク・ジェット・プリント・ヘッドの中央に沿って配置され、インク圧力室アレイの境界の外側にインク供給多岐管（第１図及び第８図参照）がある。これら正反対に設けられた入口及び出口によって、インクの充填及びパージ動作の際に圧力室のインクの流れが良好なので、インク内から泡や不純物が容易に除去される。このインクの入口及び出口の構成は、両者の距離を最大にしているので、音響的な分離度も確実に向上する。更に、インク出口はインク入口よりもノズルにより近くなり、インクが流れ易くなる。

従って、図示した構造では、圧力室間の近接した間隔よりも更に接近させた間隔で対応するノズルを配置しても良い。例えば、圧力室の中心間隔をＸとすると、これに対応するノズルの中心間隔は、上述の例から判るように、Ｘの４分の１の長さにするのが好適である。対称的構成にする為に同じ列内のノズルの間隔は、そのノズル列に対応するインク圧力室の列の数の逆数とすることが望ましい。従って、例えば、１列のノズルに対応するインク圧力室の列の数が６である場合、その列のノズルの中心間隔は、対応するインク圧力室の列の中心間隔の６分の１にすると良い。その結果、ノズルの間隔を接近させた極めて小型のインク・ジェット・プリント・ヘッドを実現することが出来る。本発明のインク・ジェット・プリント・ヘッドが小型である点をもっと具体的な例で示すと、第７図の96個のノズルを含むノズル・アレイは、長さ約3.8インチ、幅約1.3インチ、厚さ約0.07インチである。

第１図及び第３図は、第２図のインク出口多岐管44をノズル14へ接続するインク出口チャネル、即ちパージ用チャネル42も示している。通常、更に追加されたこれらのチャネル及び多岐管は、最初のジェット・インク充填動作及び気泡除去の為のパージ動作期間中のみに用いられるだけである。バルブ（図示せず）がパージ出口48を閉じるのに用いられるので、使用されない時にはパージ流経路50には流れない。リ等による米国特許第4727378号は、このようなパージ出口の詳しい構造を開示している。一般に、各インク・ジェットには、微小なノズル群14の外にパージ用のチャネル及び多岐管によってインクの通路が設けられている。その結果、気泡や他の不純物をノズルを通過させることなくインク・ジェット・ヘッドから除去することが出来る。これらの追加されたインク出口チャネル及び多岐管は、本発明のインク・ジェット・プリント・ヘッドの性能を劣化させるような影響を全く生じることがなかった。チャネル42の長さは可変であるが、好適な寸法は、長さが0.300インチ、幅が0.010インチ、厚さが0.004インチである。パージ用チャネル及び出口をなくすと、これらを構成するためのプリント・ヘッドの金属板を除去できるので、本発明のプリント・ヘッドの厚さを低減することが出来る。

第１図乃至第３図において、インク供給チャネル18は、インク圧力室22とインク・ノズル14の間の板66に形成される。インク・ジェット・プリント・ヘッドが４列のインク圧力室を有する構造であると仮定する。この場合、

圧力室の内側の２列のインク供給口がインク・ジェットの外側の２列の圧力室の間を通さなくても良いようにするには、圧力室間の間隔を増加する必要が生じ、インク供給口はインク圧力室の下側に位置する板の圧力室につながる。即ち、インク供給口は、インク・ジェット・ヘッドの外側から圧力室及びノズルの間の板の中へ延びている。これらインク供給口は、圧力室と夫々位置が一致するように設けられ、圧力室の下側から圧力室に接続されている。

内側の列の圧力室の入口チャネルの流体インピーダンスを外側の列の圧力室の入口チャネルの流体インピーダンスと等しくするために、これらのチャネルは、同じ断面及び同じ長さを有する２つの異なる構造で作ることが出来る。即ち、第１図、第３図、第８図及び第13図の102a及び102bの構造に留意されたい。入口チャネルの長さ及びそれらの断面積によって流体に対する特性インピーダンスが決まり、これは、インク・ジェット・ヘッドの所望の性能を達成するように選択し、圧力室の入口20を小さい孔又はノズル状にする必要を回避する。代表的な入口チャネルの寸法は、長さ0.275インチ、幅0.010インチ、そして厚さがインクの粘性に応じて0.001～0.016インチ程度である。インクの粘性は、水性インクの場合で約１～15センチポアズ、ホット・メルト・インクの場合で約10～15センチポアズ程度である。ここで重要なことは、インク・ジェット・プリント・ヘッドを所望の最高速度で動作させるに十分なインクを供給出来、且つインク圧力室の音響的な分離状態を良好に維持するようにインク入口の大きさを決めることである。

入口用多岐管及び出口用多岐管は、４列の圧力室の境界の外側に配置するのが望ましい。更に、これらの多岐管の断面の寸法は、インクの体積を最少にしながら、全てのインク・ジェット・ノズルを同時に駆動したときにノズルに十分なインクを供給出来、且つ、ジェット・ノズル間の相互作用を最少に出来る程のコンプライアンスを維持するように最適化される。この多岐管の代表的な断面の寸法は、0.12×0.02インチである。出口チャネル及び出口多岐管をなくせば、圧力室とノズルの間の入口用多岐管をオフセット・チャネル71と同じ層に配置することにより本発明のインク・ジェット・プリント・ヘッドを更に小型化することが出来る。この例は、第４図及び第５図に示している。この後者の構造の利点は、圧力室の内側の列と外側の列の両方の入口チャネル18同じ構造、即ち同じ断面且つ同じ長さで良いことである。出口チャネルをなくすと、層72は、薄いノズル層を更にしっかりと支持することが可能になる。圧力室の外側の列の下に入口多岐管を完全に配置すると、最初の４列の圧力室と同じ六角形の配列を拡張して更に多くの圧力室の列を設けることが出来る。即ち、層62の中に更に多くの数の圧力室を形成することが可能になる。この例を第６図に詳細に示している。更に、第９図～第18図は、第８図に示したインク・ジェット・プリント・ヘッドに好適な種々の層の構造を示す図である。

複数のインク供給チャネルに各多岐管からインクが供給されるが、本発明の設計によれば、共通の多岐管に接続されたインク圧力室間が音響的に分離される。即ち、上述の構造において、インク供給多岐管及びインク供給チャネルは実質的に音響的RC回路として機能し、圧力パルスを減衰させる。このような圧力パルスはインク圧力室で発生し、その圧力室から入口チャネルを介して共通多岐管へ逆行し、多岐管の隣の入口チャネルに入り得るものであり、隣のジェット・ノズルへ悪影響を与える虞がある。本発明では、これらの多岐管によりコンプライアンスの効果が得られ、更に入口チャネルにより音響的な分離効果が得られるので、これらの圧力室は互いに音響的に分離されている。音響的に分離されているということは、１つのジェット・ノズルのインク噴射特性が同じ多岐管に接続された他のジェット・ノズルの動作から何等影響を受けないことを意味する。この音響的分離は、インク滴の噴射周期が10μ秒以下で達成されることが観測され、通常は３μ秒以内の周期で達成された。この程度のクロストークでは、プリント結果には何等影響を与えることはない。

本発明のインク・ジェット・プリント・ヘッドのインク流の経路をより正確に辿るために、第１図及び第３図を参照して説明する。

インクは、インク入口12（層60）を介してインク多岐管130（層62及び64）に供給される。多岐管130からのインクは、入口チャネル102a（層66）の１つの入口132aに供給される。入口チャネル102aからのインクは、圧力室の入口20a（層66及び64）を介して圧力室22a（層62）へ送られる。インク滴噴射パルス又はパージ動作に応じて、インクは、圧力室22aから接続通路100a（層64、66及び68）、オフセット・チャネル71a（層70）、及び通路104a（層72及び74）を介してノズル14a（層76）へと流れる。保護板78の開口136aは、ノズル14aの位置に合わせて設けられており、ノズル14aよりも大きい。パージ動作中に、インク通路104aに達したインクの大部分は、パージ・チャネル42aを介してノズルから通路138a（層74及び72）へ送られる。これらの通路は図示したように拡大され、パージ用多岐管44に接続される。パージ用多岐管44からパージ用出口46（層68～60）を介してインクが出力される。

同様に、多岐管130からインクが入口チャネル102bの１つの多岐管の入口132b（層66）へ流れ、入口チャネル120bからのインクは、圧力室入口20b（層66及び64）を介して圧力室22bへ供給される。圧力室22bからのインクは、接続通路100b（層64、66及び68）、オフセット・チャネル71b（層70）及び通路104b（層72及び74）を介してノズル14b（層76）へ送られる。保護板78に設けられた開口136bを介してノズル14bからのインク滴が射出さ

れる。パージ動作中に、通路104bに到達したインクの大部分が、パージ・チャネル42bを介して通路138b（層74及び72）からパージ用多岐管44へ送られる。この多岐管44からのインクは、上述のように、パージ出口46を介してプリント・ヘッドから流れ出る。

第１図のインク・ジェット・プリント・ヘッドにおいて、下側及び下側のインク供給多岐管130及び130′並びに上側及び下側のインク・パージ用多岐管44及び44′がある。残りのノズルへのインク流経路は、上述の説明から容易に理解出来よう。第１図のインク・ジェット・プリント・ヘッドは、通常黒色インクをプリントするのに用いられるが、２つのカラーのインクをプリントするのに使用可能であり、その場合には、第１図の上側の多岐管130′に一方のカラー・インクを供給し、他方のカラー・インクを下側の多岐管130に供給すれば良い。

同様にして、第４図及び第５図のインク流経路を辿ってみよう。説明の便宜上、第１図の各要素に対応するこれらの図面の要素には同じ参照符号を付している。第４図及び第５図において、インクはインク入口12（層60、62、64、66及び68）から層70の多岐管130に流れる。同様の入口12′はこれらの層から上側のインク多岐管130′に延びている。多岐管130からのインクは、通路132a（層66及び68）を介してインク入口チャネル102aの一端へ供給される。チャネル102aからのインクは、通路20a（層66及び64）を介して圧力室22aの下端のインク入口に供給される。圧力室22aの上端からのインクは、通路100a（層64、66及び68）を通って層70のオフセットａチャネル71aの下端に供給される。このオフセット・チャネルの上端からのインクは、通路104a（層72）を介してノズル14a（層76）へ送られる。保護板78の開口136aは、出力口、即ちノズル14aを囲むように、その位置に合わせて設けられている。

インク圧力室22bへ向かうインク流経路及びこのインク圧力室22bから対応するノズル14bへのインク流経路は、上述のインク流経路と同様である。従って、このインク流経路の要素は、上述の対応する要素と同じ参照番号に添え字ｂを付しており、これ以上の説明は省略する。第１図インク・ジェット・プリント・ヘッドのように、第４図のプリント・ヘッドは、単一のカラー（例えば黒色）又は２つのカラーのインクのプリント用に用いられる。更に、上述のように、第４図の実施例では、パージ用多岐管及びパージ・チャネルを除いている。

第６図は、本発明を拡張して容易に得られるインク・ジェット・プリント・ヘッドの分解斜視図である。このプリント・ヘッドはより多くのカラー・インクの為に更に多くの多岐管を有しているが、圧力室22及びインク・ジェット・ノズルの近接間隔を保持している。

層70に設けられた多岐管130、130′、130″及び130‴の各々に、夫々入口12、12′12″及び12‴を介してインクが供給される。これら４つの多岐管は夫々黒色、シアン、マゼンタ及びイエローに対応しているが、これらの順序はどうでもよい。これらの種々のインク圧力室に関するインク流経路の詳細は、第４図について説明したのと同様であるので更に説明する必要はないであろう。しかし、便宜上、第４図の参照符号に対応する参照符号を付した圧力室22a及び22bに関連する要素のインク流経路を図示している。

第８図のインク・ジェット・プリント・ヘッドは、タイプライターに類似の往復プリンティング機構に用いられている。この機構は、水平及び垂直の両方向に300ドット／インチのプリント密度でフルカラー・プリントをすることが出来る。このプリント・ヘッドは、ノズル当たり１秒間に約11000個のインク滴をプリントする速度まで信頼出来る動作が維持されることが確認された。第８図のインク・ジェット・プリント・ヘッド黒インクをプリントするのに用いられる48個のノズルの列を有する。このプリント・ヘッドは、更にカラー・インクをプリントするのに用いられる48個のノズルの列も有し、この列は黒インク用に列と分離され、水平方向にずれた位置に設けられている。これらカラー用の48個のノズルの中の16個のノズルは、シアン・インク用であり他の16個のマゼンタ用であり、残りの16個はイエロー用である。

第８図のプリント・ヘッドのレイアウトは、２列でなく１列のノズル構成に容易に変更可能である。このインク・ジェット・プリント・ヘッドの動作特性は、この変更をしても何等影響を受けることはない。

第９図乃至第18図は、第８図の96個のノズルを有するインク・ジェット・プリント・ヘッドの為の各部の図である。第９図は、変換器を装着するスペーサ板59、第10図は、隔壁板60、第11図は、インク圧力室板62、第12図は、分離板64、第13図は、インク入口板66、第14図は、分離板68、第15図は、オフセット・チャネル板70、第16図は、分離板72、第17図は、ノズル又は出力口板76、及び第18図は、保護板78を夫々示している。この第８図のプリント・ヘッドは、種々のカラー・インクを受ける多数のインク受け多岐管を備えるように設計されている。図示した例では、５セットの多岐管を有し、各セット毎に２つの多岐管セクションが含まれている。これらの多岐管セットは互いに分離されているので、このインク・ジェット・プリント・ヘッドは５種類のカラー・インクを受けることが出来る。従って、例えば、このインク・ジェット・プリント・ヘッドは、フルカラープリントの為のシアン・マゼンタ及びイエローの減法混色の３原色のインク及びテキストのプリントの為の黒インクを受けることが出来る。５番目のカラー・インクとしては、プリント媒体上にシアン、マゼンタ及びイエローを混合して作った５番目のカラーを用いても良い。また、黒インクは、通常、テキストや図形をプリントする際にカラー・インクより多く使用されるので、２つ以上の多岐管セットに黒インクを供給するようにしても良い。この具体

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的な応用例を以下に説明する。更に、各カラー・インク用に複数の多岐管セクションを設けることにより、個々の多岐管セクションと、多岐管セクションからインクが供給される対応するノズルとの間の距離を最小にすることが出来る。これにより、例えばプリント中に水平方向に沿ってインク・ジェット・プリント・ヘッドが往復する際にインク滴を加速及び減速することにより発生するインク圧力の動的変化を最小に抑制出来る。

本発明の第８図の実施例を構成する種々の層を流れるインクの経路について第９図乃至第18図を参照して説明する。

第９図は、第８図の圧電セラミック変換器36が装着される開口140を有するスペーサ板59を示している。このスペーサ板59は、任意部品であり、圧電セラミック結晶の外側表面と共面関係となってインク・ジェット・プリント・ヘッドの後ろ側を平面状にするものである。プリント・ヘッドにインクを供給する為の複数のインク供給口をこの層59を貫通するように設ける。これらのインク供給口は、12c（ｃはシアンのカラー・インクの供給口を示す）、12y（ｙはイエローを示す）、12m（ｍはマゼンタを示す）、12b1（b1は第１黒色インクを示す）及び12b2（b2は第２黒色インクを示す）の参照符号で示される。便宜上、以下の説明において、ｃ、ｙ、ｍ、b1、及びb2は、夫々シアン、イエロー、マゼンタ、第１黒色及び第２黒色の各インクの流れる経路に関連する部品を示す為に用いる。これら種々のカラー・インクは、ここに記載した順序でインク・ジェット・プリント・ヘッドに供給する必要は全くないことに留意されたい。しかし、後述するように、第８図～第18図に示したインク・ジェット・プ・ヘッドは、プリント・ヘッドの左側のセクションのカラー・プリントの為の48個のノズル群と、プリント・ヘッドの右側セクションの黒色プリントの為の48個のノズル群とを有する。

第10図の隔壁60において、インク供給口12c～12b2は、夫々この層60を貫通している。

第11図において、シアンの供給口12cは、２つのシアン多岐管セクション130c及び130c′に通じるシアン・インク供給チャネル142に接続されている。多岐管セクション130cは、圧力室22の左側アレイの外側の下側の中央部分に隣接するように設けられている。多岐管セクション130c′は、圧力室の左側アレイの左上の部分に隣接して配置されている。更に、この層62のインク供給口12b2は、黒インク多岐管セクション130b2及び130b2′に接続されたチャネル144に通じている。多岐管セクション130b2は、圧力室22の右側アレイの右下部分に隣接して設けられ、多岐管セクション130b2′は、圧力室22の右側アレイの右上部分に隣接して設けられている。

イエロー・インク供給口12yは層62のチャネル146に通じている。尚、第11図のイエロー・インク多岐管セクション130y及び130y′へのイエロー・インクの接続は別の層

20

で行われる。また、マゼンタ・インク供給口12m及び第１黒インク供給口12b1は、この層62を貫通している。これらのインク供給口は、夫々マゼンタ及び黒インク多岐管、即ち第11図で130m、130m′、130b1及び130b1′で示された部分にプリント・ヘッドの他の層の中で接続されている。分離した多岐管セクション間に142、144及び146の番号で示すような連絡チャネルを設けることにより、必要なインク供給ポートの数は10個ではなく僅か５個だけで良い。更に、２以上の層にまたがって多岐管を設けることにより、多岐管の深さ即ち容積を増加させ、それにより音響的なコンプライアンスを向上することが出来る。

第12図から判るように、第11図の層62の多岐管及び連絡チャネルの位置に合わせて、層64の同様の多岐管及び連絡チャネルを配置している。同様に、第13図の層66では、インク供給多岐管の部分が層66にまで及んでいるので多岐管の音響的コンプライアンスが更に増加される。また、層66は、通路12y及び12y′も含んでいる。これらの通路は第11図及び第12図の層62及び64の連絡チャネル146の端部に通じている。また、これらの多岐管の容積の増加及び音響的コンプライアンスの増加は、この層66によって制限される。

第14図及び15図において、マゼンタ・インク供給口12mは連絡チャネル148に接続され、このチャネルを介してマゼンタ多岐管セクション130m及び130m′に接続されている。更に、イエロー・インク供給口12yは、チャネル150を介して多岐管セクション130y（第14図）に接続されている。また、インク供給口12y′は、チャネル154を介してイエロー・インク多岐管セクション130y′（第15図）に接続されている。更に、黒インク供給口12b1は、通路156を介して層68及び70（第14及び15図）に接続され、更にこの通路を介して黒インク多岐管セクション130b1及び130b2に通じている。

従って、上述の方法で各インク多岐管セクションにインクが供給される。また、個々の多岐管セクションの容積は多層領域にまたがって多岐管セクションの部分を設けることにより増加している。

これらの多岐管セクションからインクが選択された黒、シアン、マゼンタ及びイエローのインク圧力室22b1、22b2、22c、22m及び22yに供給される経路について更に説明する。また、これらのインク圧力室からそれらに対応するノズルへのインク流の経路についても説明する。この説明から他の圧力室及びノズルへのインク流経路も容易に理解出来よう。

第13図及び第14図において、シアン・インク多岐管セクション130c′からのインクはインク供給チャネル102cのインク供給口132cへと流れる。チャネル102cからのインクは、インク圧力室の供給口20c（第12図及び13図の層64及び66）を通ってインク圧力室22c（第11図の層62）の上側部分に供給される。インクが圧力室22cを通って通

路100c（第12、13及び14図の層64、66及び68）へと流れ、更にオフセット・チャネル71c（第15図の層70）へと流れる。オフセット・チャネル71cの下端部からインクが開口104c（第16図の層72）を介して対応するノズル14c（第17図の層76）に流れる。このノズル14cは、開口136cの位置に合わせて被覆保護層78（第18図）に設けられている。

同様に、イエロー・インク多岐管セクション130y（第14図）からのインクは、インク供給チャネル102yの入口132y（第13図）へと流れる。インク供給チャネル102yからのインクは、通路20y（第13及び12図の層66及び64）を通ってインク圧力室22yの上側部分に供給される。このインク圧力室の下側部分からのインクは、通路100y（第12、13及び14図の層64、66及び68）を通ってオフセット・チャネル71（第15図の層70）の下端部に流れる。このオフセット・チャネルの上端部からのインクは、開口104y（第16図の層72）を介してノズル14y（第17図の層76）へと流れる。保護層78の開口136yは、ノズル口14yに重なっている。同様に、インク圧力室22m、22b1及び22b2に出入りするインクの経路に関連する要素の参照番号には、夫々対応する添え字m、b1及びb2を付している。

第８図、第15図及び第17図において、上述の多岐管の配置により、第15図の右側アレイの48個のオフセット・チャネルには、第17図の板46のノズルの右側列に含まれる48個のノズルに沿って黒インクが供給される。更に、第15図の左側のオフセット・チャネル・アレイの上側の列の最初の８個のオフセット・チャネルには、シアン・インクが供給され、その隣の８個のオフセット・チャネルにはマゼンタ・インクが供給され、同じ列の更に第３グループの８個のオフセット・チャネルにはイエロー・インクが供給される。更に、左側のオフセット・チャネル・アレイの下側列の最初の８個のオフセット・チャネルにはイエロー・インクが供給され、次の８個のオフセット・チャネルにはシアン・インクが供給され、その次の８個のオフセット・アレイにはマゼンタ・インクが供給される。このように第15図のオフセット・チャネルの上下の列をインタリーブ方式で構成することにより、この構造を有する第17図のプリント・ヘッドのノズルにはインタリーブ方式で割り当てられたカラー・インクが供給される。即ち、第17図の左側の列のノズル群の垂直方向で隣合う各ノズルには異なる色のインクが供給される。この構成により、ある色のインクのノズルの垂直間隔が少なくとも２ドット分離れるので、カラー・プリンティングが容易になる。このような多岐管の配置及びインク供給方法を採用することにより、ノズルにインタリーブ方式で供給する色の配列を所望により容易に変更することが可能である。

このように、第８図の本発明の実施例は、小型で製造が容易で種々の優れた機能を有するインク・ジェット・プリント・ヘッドを実現している。

以上本発明の好適実施例について説明したが、本発明はここに説明した実施例のみに限定されるものではなく、本発明の要旨を逸脱することなく必要に応じて種々の変形及び変更を実施し得ることは当業者には明らかである。

［発明の効果］

本発明によれば、１列に配置された複数のノズルの各々に対する円形のインク圧力室の各々の幾何学的中心が少なくとも３つの交差しない列の１つの上になるように、インク圧力室が配置され、１つの列の上のインク圧力室の幾何学的中心は隣接した他の列の上のインク圧力室の幾何学的中心とずれている。よって、１列に配置された複数のノズルを接近させることができる。また、単に整然とマトリクス状に配列する場合より、インク圧力室の列に垂直な方向の寸法を小さくすることが出来、極めて小型のインク・ジェット・プリント・ヘッド装置を実現出来る。これらインク圧力室の列の方向は任意に調整出来るので、所望により垂直、水平又は傾斜方向等、任意の方向の寸法を小さくすることが出来る。更に、これらのインク圧力室のインクを駆動する駆動手段もインク圧力室の配置に対応して効率的に配置することが出来る。また、ヘッド全体が多層板構造なので製造が容易である。

【図面の簡単な説明】

第１図は、本発明のインク・ジェット・プリント・ヘッドの好適実施例の分解斜視図、第２図は、本発明の基本となる単一ノズルのインク・ジェット・プリント・ヘッドの図、第３図は、第１図のインク・ジェット・プリント・ヘッドの種々の層に亘る構成を平面的に示す模式図、第４図は、本発明の他の好適実施例を示す分解斜視図、第５図は、第４図のインク・ジェット・プリント・ヘッドの種々の層に亘る構成を平面的示す模式図、第６図は、本発明の更に別の実施例の分解斜視図、第７図は、インク圧力室、インク供給口、インク出力通路、及びオフセット・チャネルを重ねて示す模式図、第８図は、本発明の他の実施例分解斜視図、第９図乃至第18図は、第８図のインク・ジェット・プリント・ヘッドを構成する各層の平面図である。

60:第４の板（隔壁層）
62:第２の板（インク圧力室層）
64、66、68、70、72:第３の板（インク通路層）
76:第１の板（ノズル層）

【第１Ａ図】

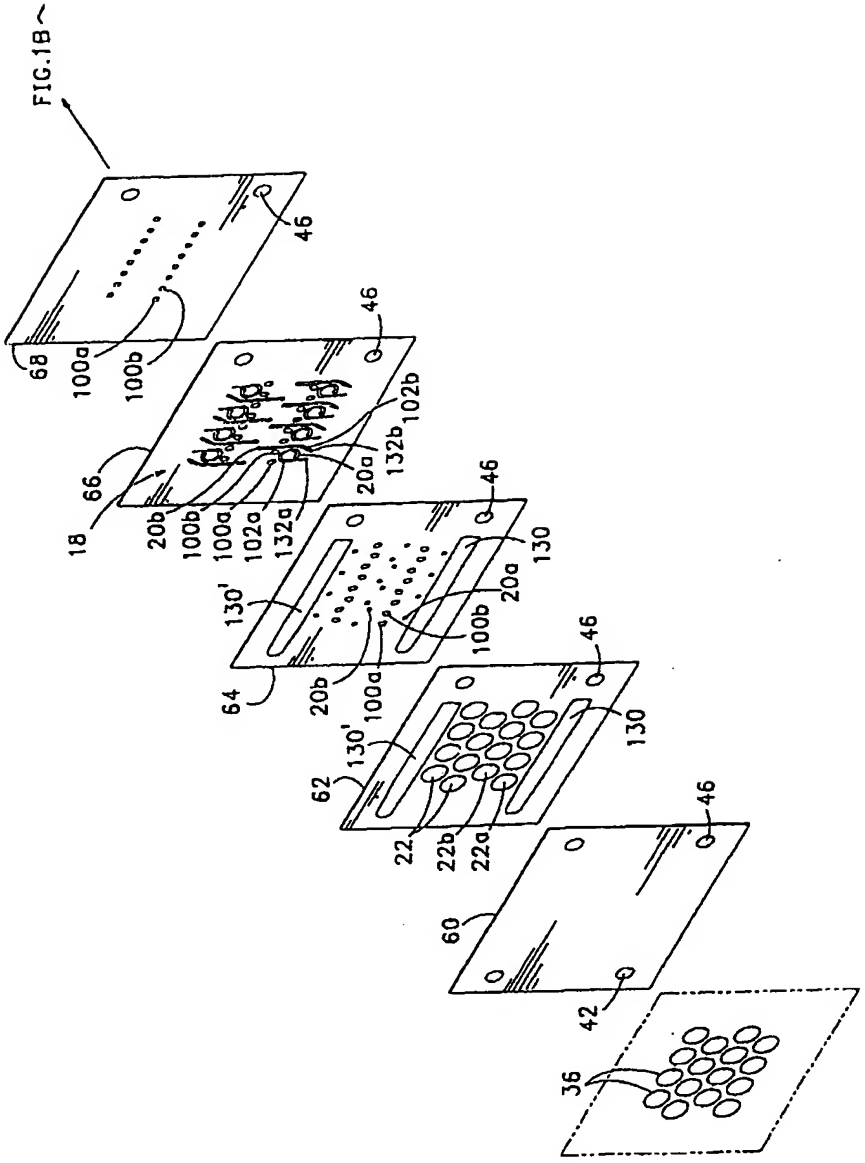


FIG.1B
46
68
100a
100b
102b
132b
20a
66
18
20b
100b
100a
102a
132a
130
130'
64
62
22
22b
22a
60
42
36

【第１Ｂ図】

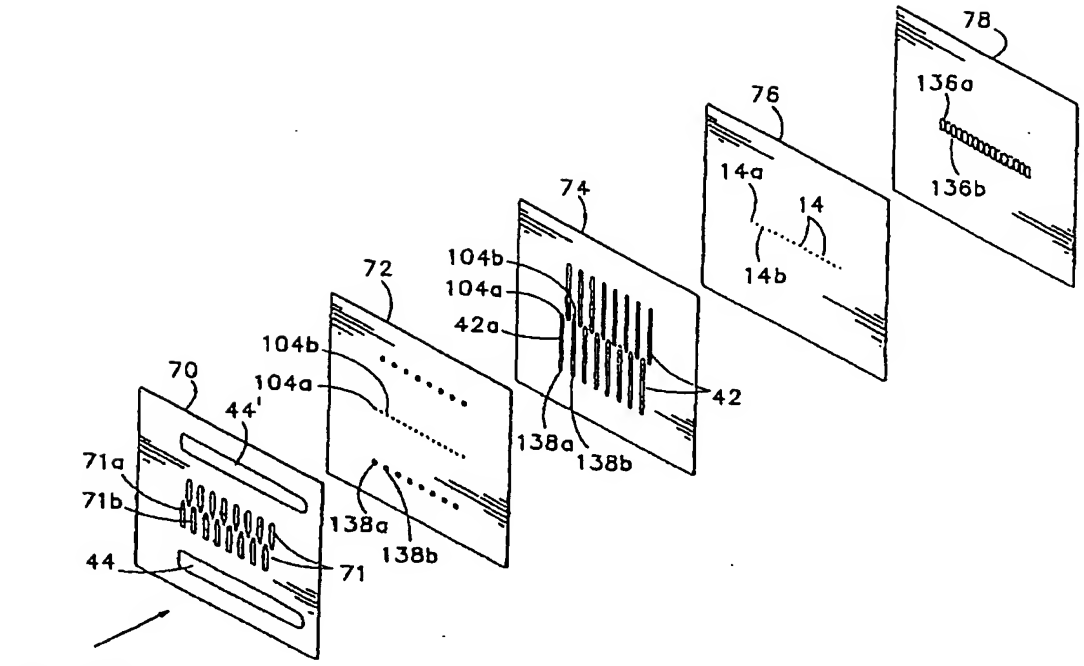
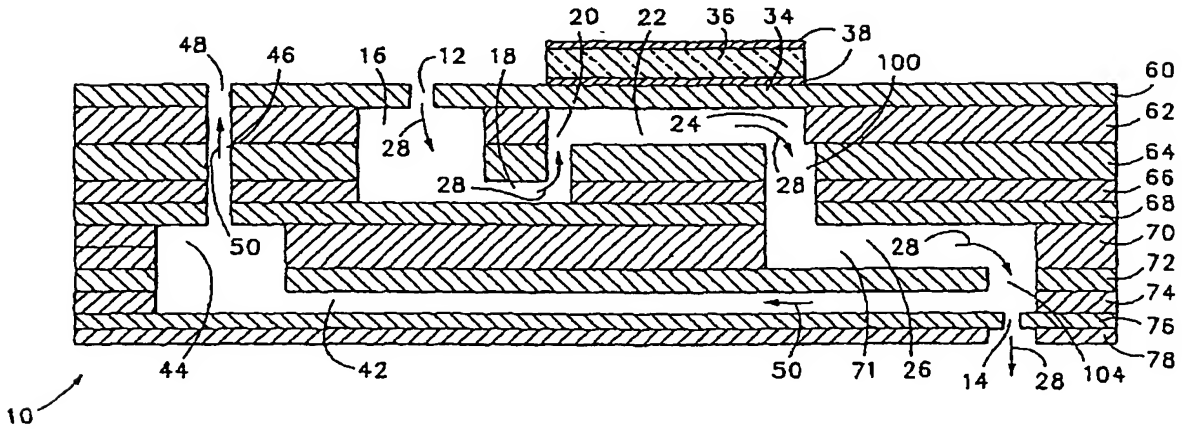
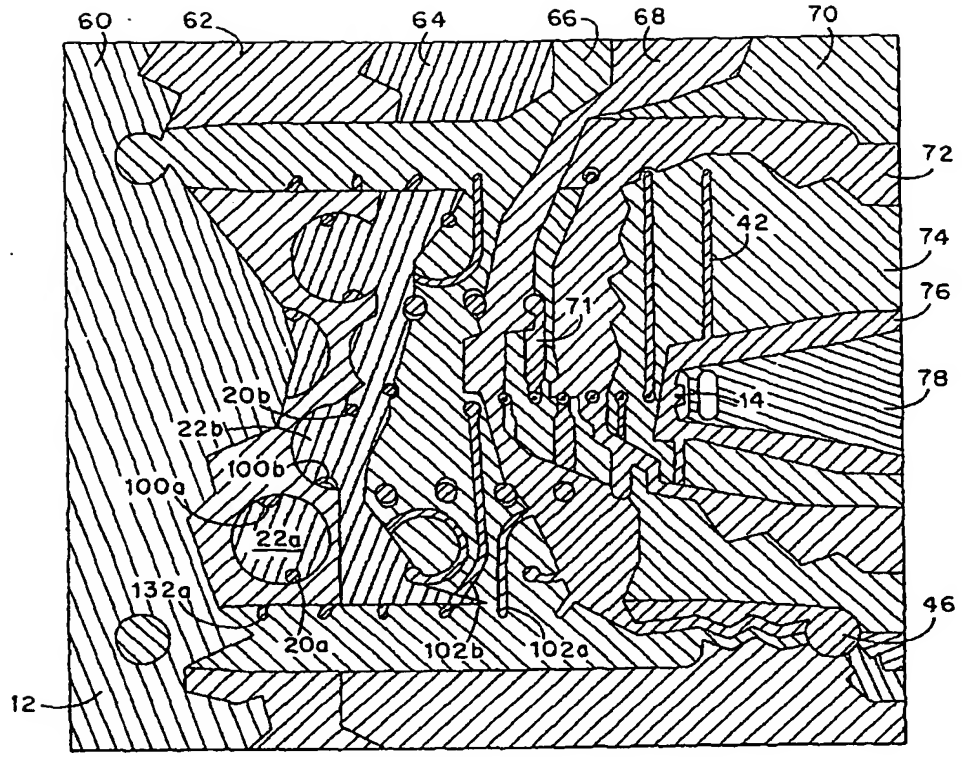


FIG.1A から

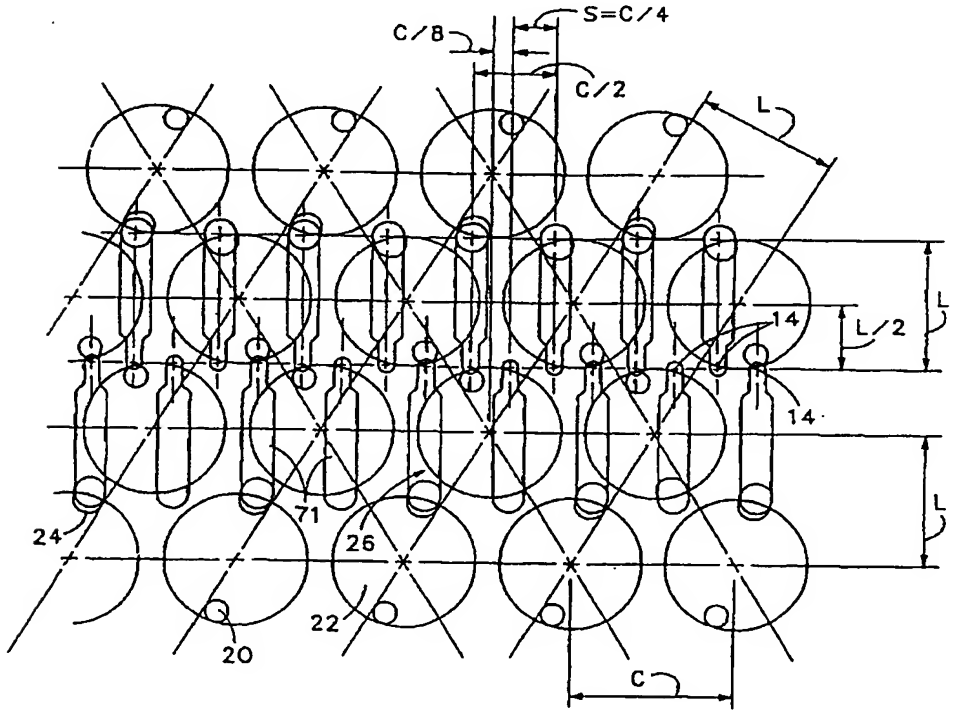
【第２図】



【第３図】


60
62
64
66
68
70
72
42
74
71
76
78
14
20b
22b
100b
100a
22a
132a
20a
102b
102a
46
12

【第７図】


S=C/4
C/8
C/2
L
L
L/2
L
14
14
71
26
24
22
20
C

【第４Ａ図】

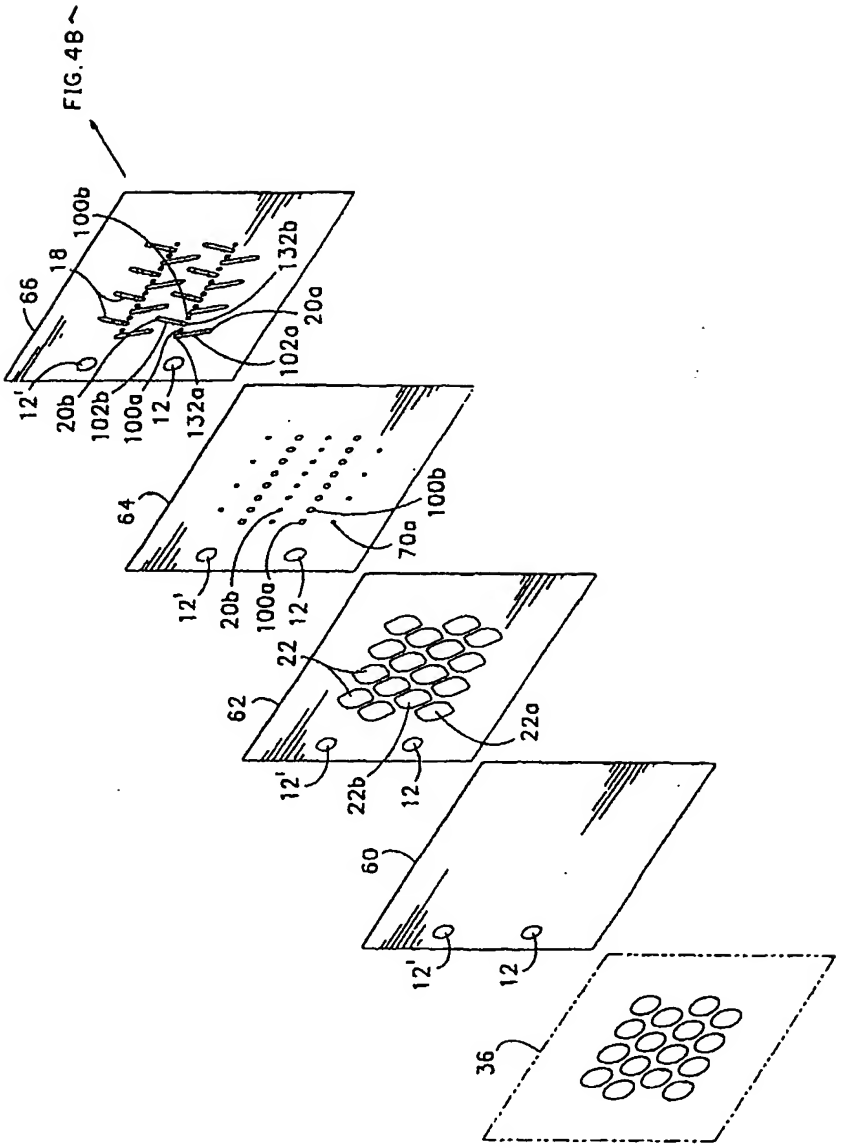
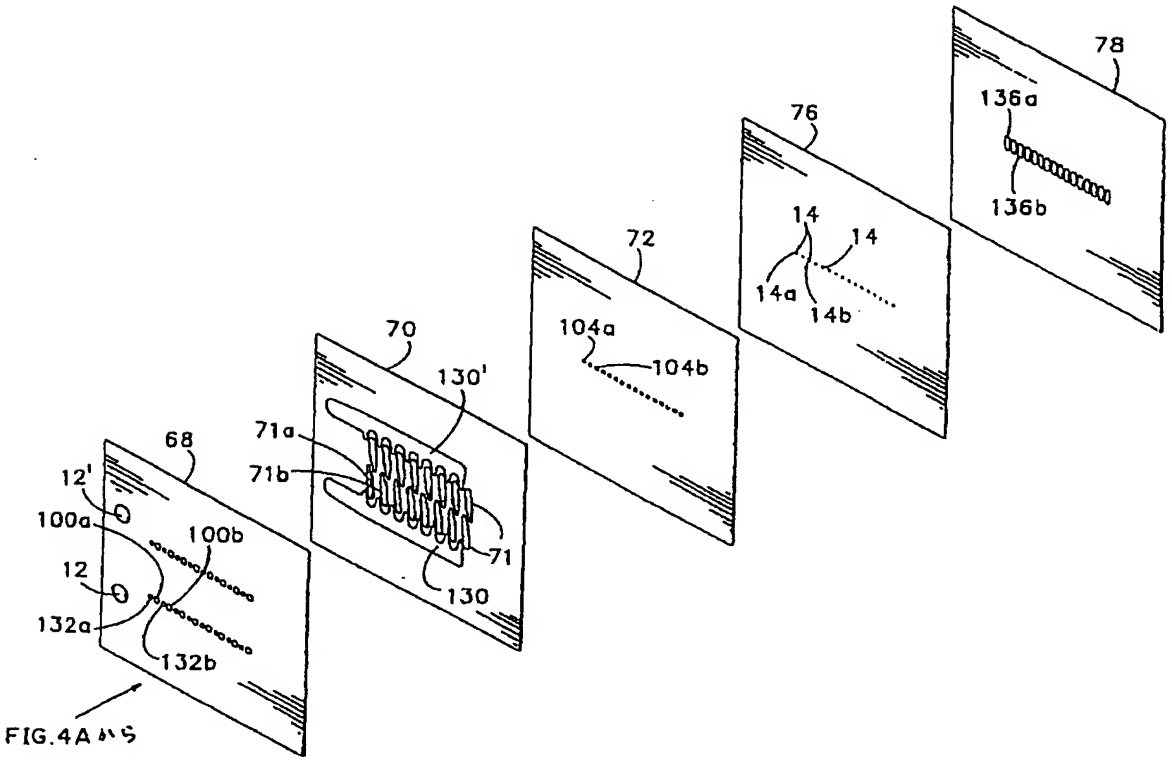
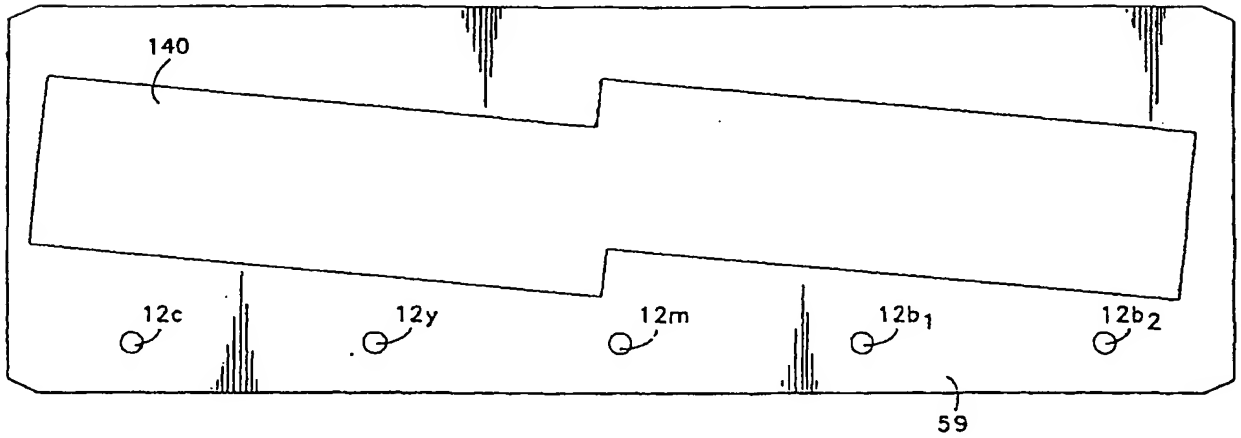


FIG. 4B
66
18
100b
132b
20a
102a
12'
20b
102b
100a
12
132a
64
70a
22
62
22a
22b
60
36

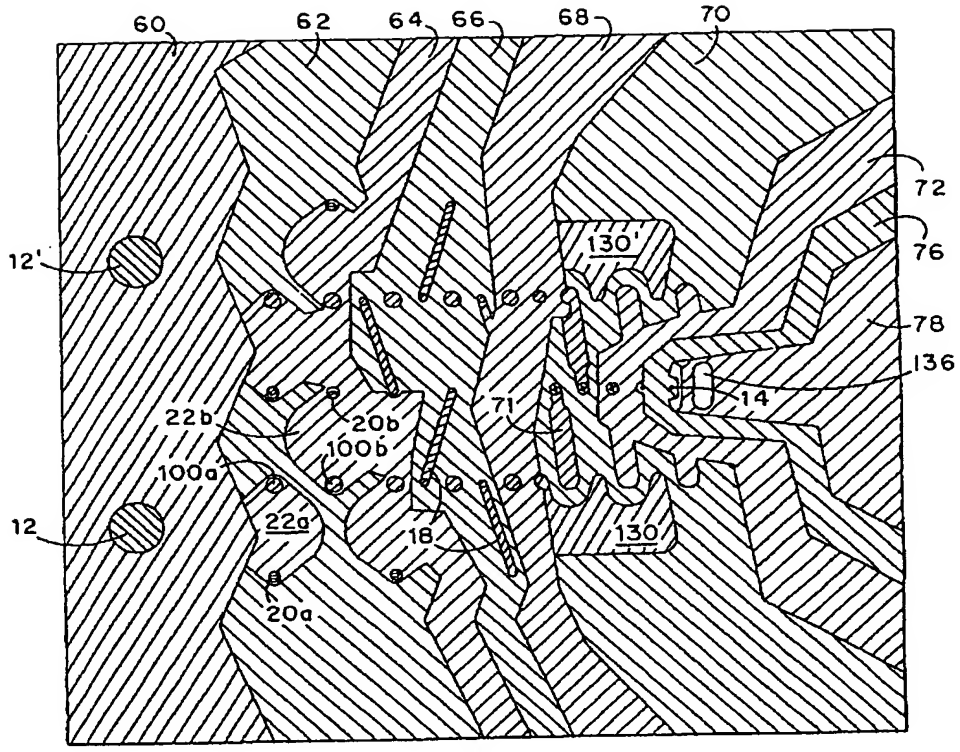
【第４Ｂ図】


78
136a
136b
76
14
14
14a
14b
72
104a
104b
70
130'
71a
71b
71
130
68
12'
100a
100b
12
132a
132b
FIG.4Aから

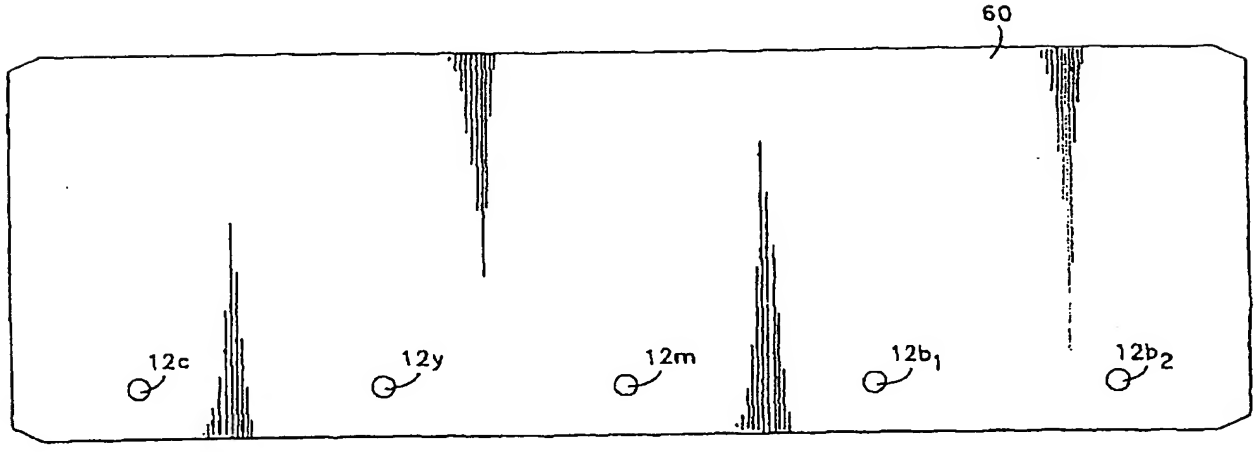
【第９図】


140
12c
12y
12m
12b1
12b2
59

【第５図】


60
62
64
66
68
70
72
76
78
136
14
130'
12'
12
22b
20b
100b
100a
71
22a
18
130
20a

【第１０図】


60
12c
12y
12m
12b1
12b2

【第６Ａ図】

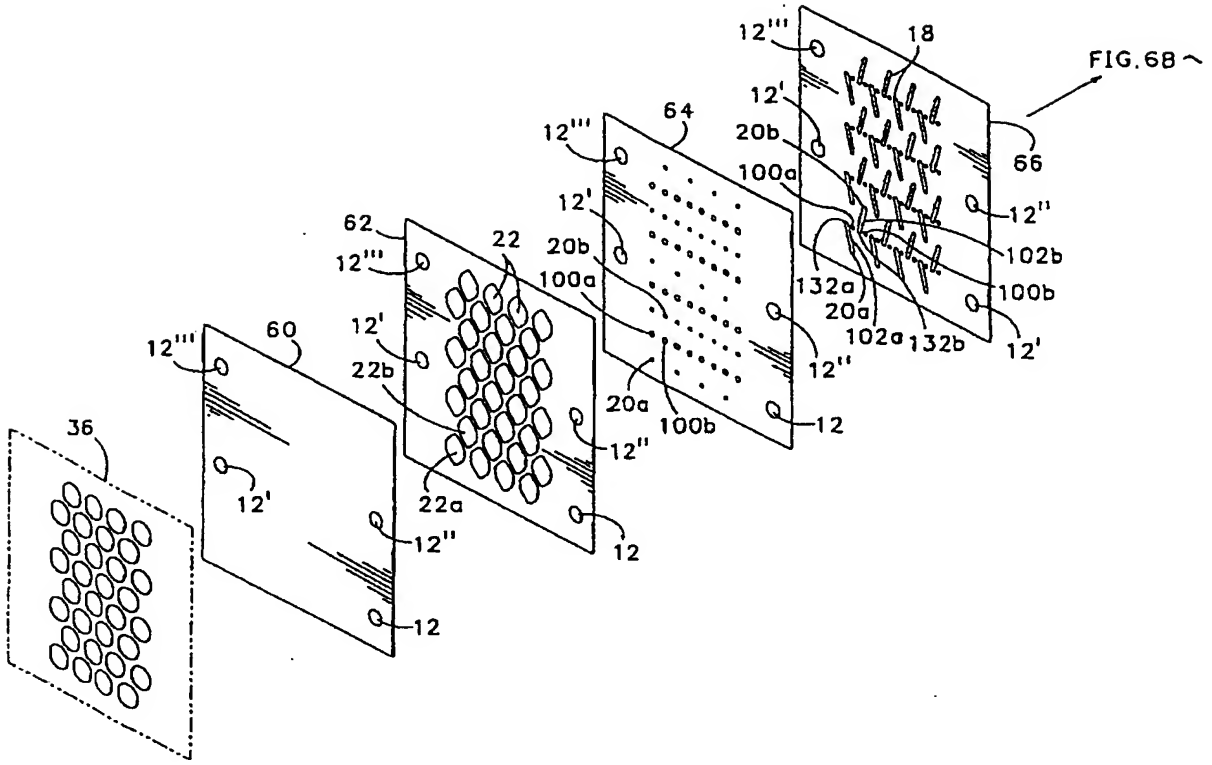
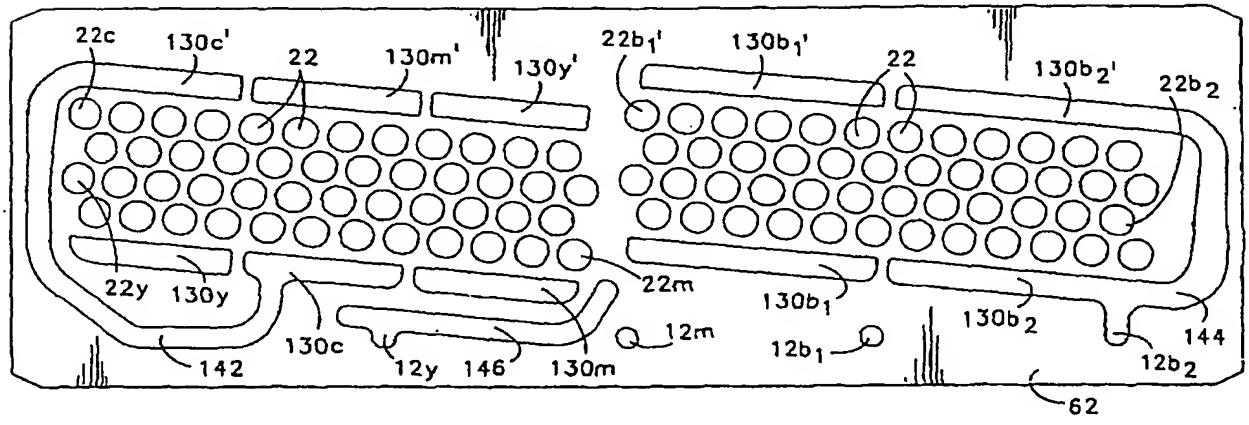
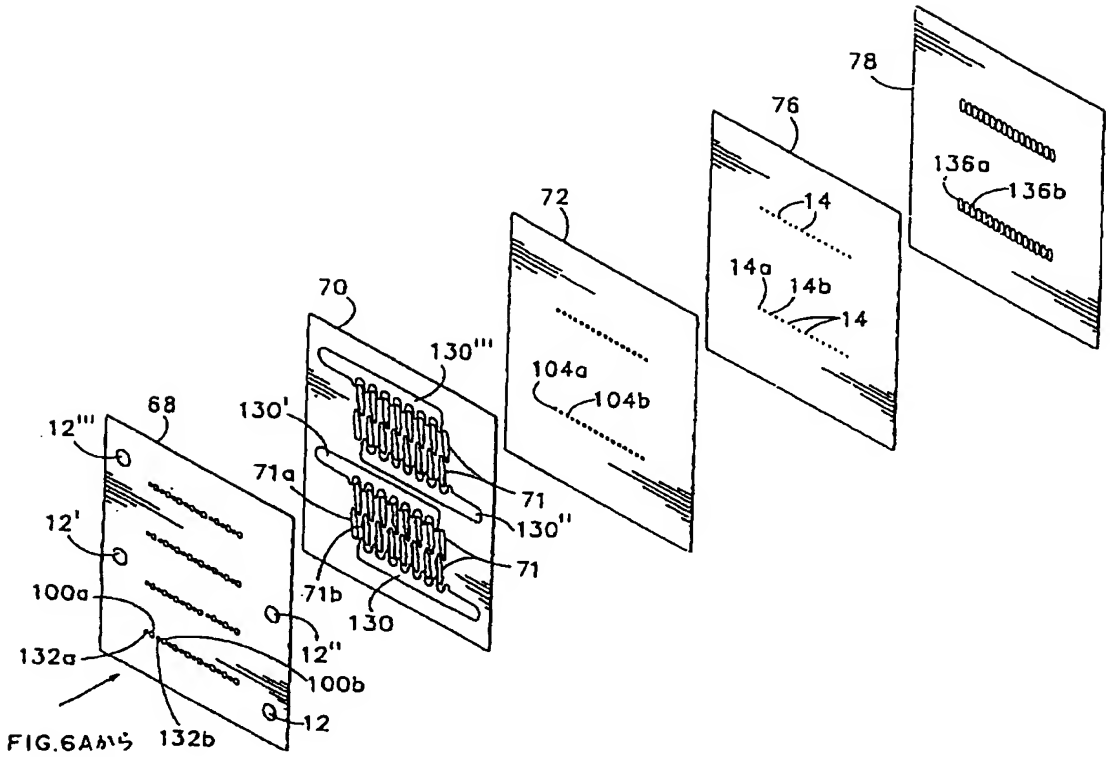


FIG.6B
12'''
18
12'
20b
100a
66
12''
102b
100b
132a
20a
102a
132b
12'
64
12'''
12'
20b
100a
12''
20a
100b
12
62
12'''
22
12'
22b
22a
12''
12
60
12'''
12'
12''
12
36

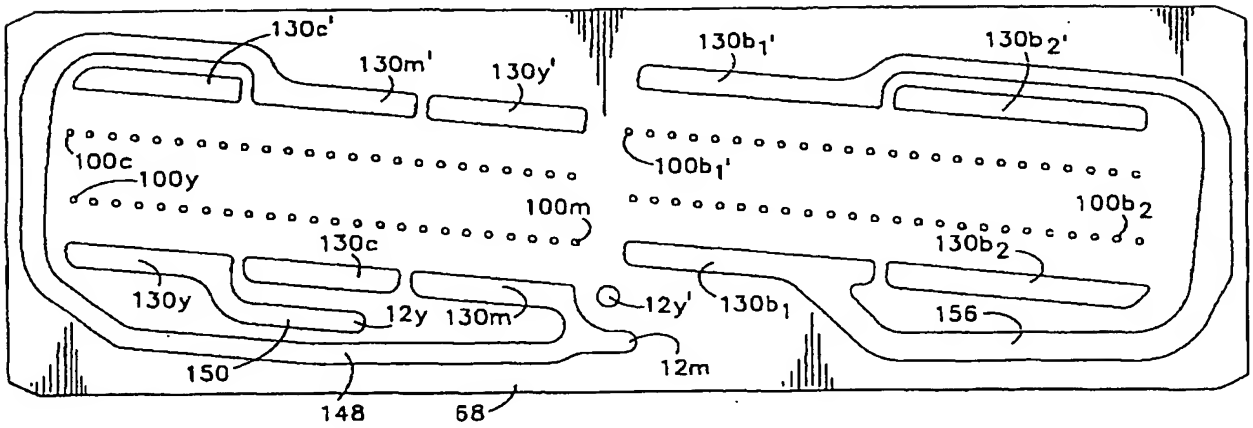
【第１１図】


22c
130c'
22
130m'
130y'
22b1'
130b1'
22
130b2'
22b2
22y
130y
22m
130b1
130b2
144
12m
12b1
12b2
142
130c
12y
146
130m
62

【第6B図】


78
76
136a
136b
72
14
14a
14b
14
70
130'''
104a
104b
68
12'''
130'
71a
71
130''
12'
71
71b
130
100a
12''
132a
100b
12
FIG.6Aから
132b

【第14図】


130c'
130m'
130y'
130b1'
130b2'
100c
100y
100b1'
100m
100b2
130c
130b2
130y
12y
130m
12y'
130b1
156
150
12m
148
68

【第８Ａ図】

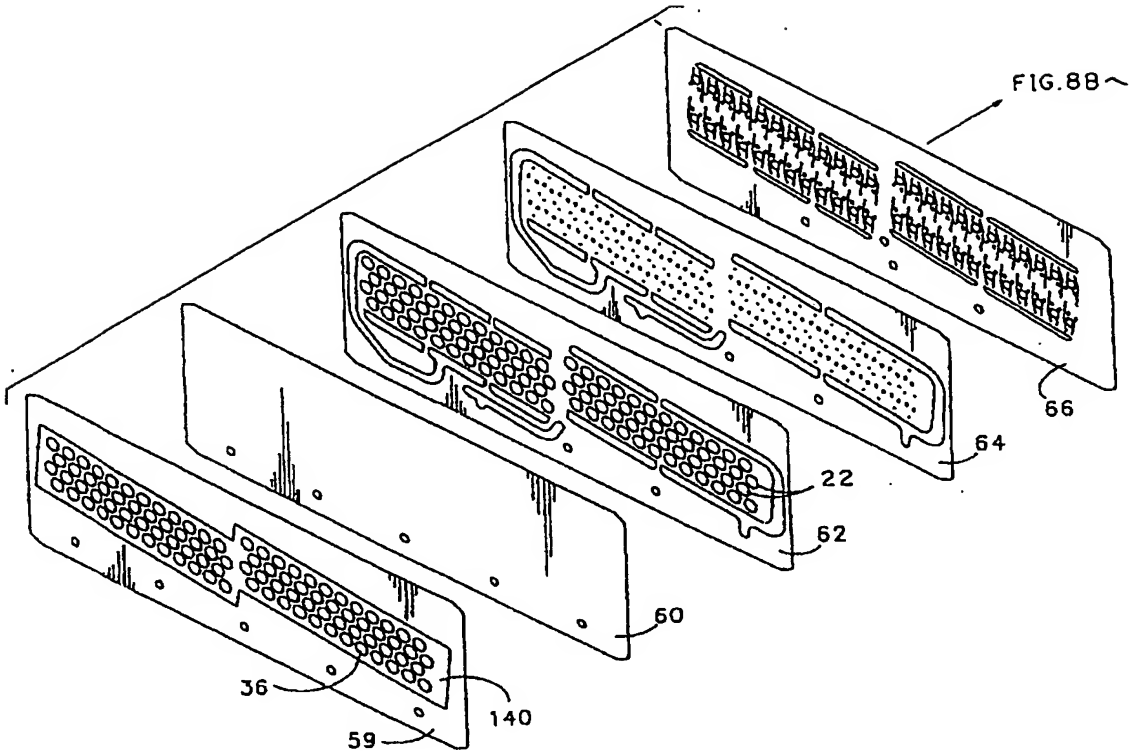
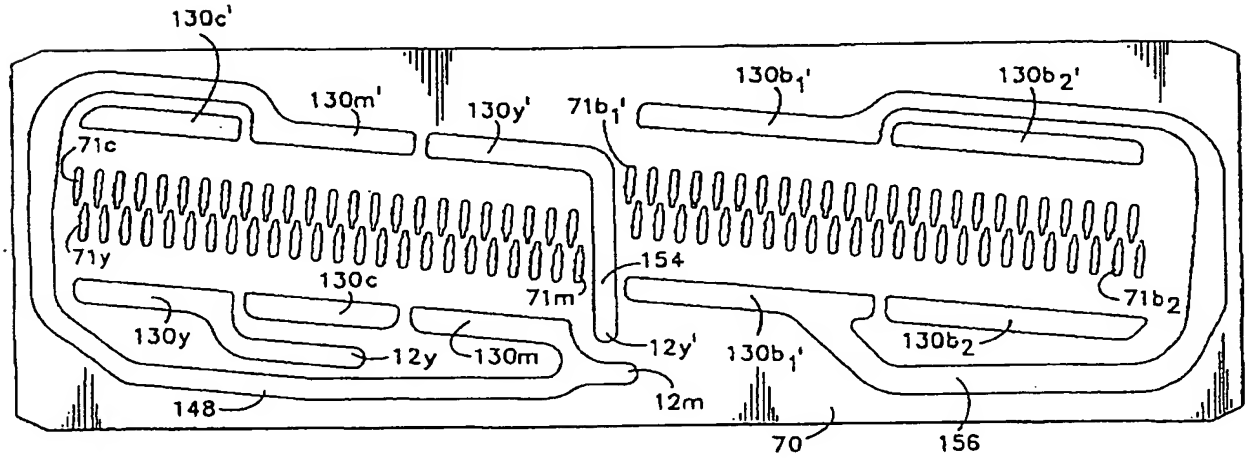
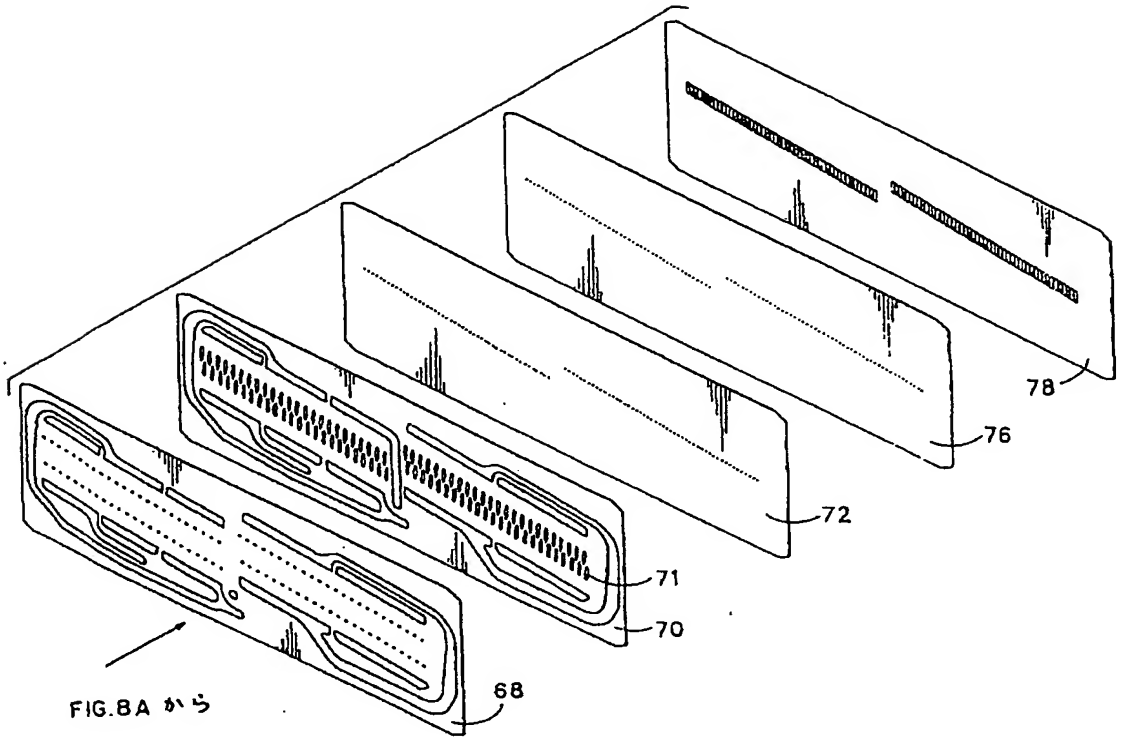


FIG.8B
66
64
22
62
60
36
140
59

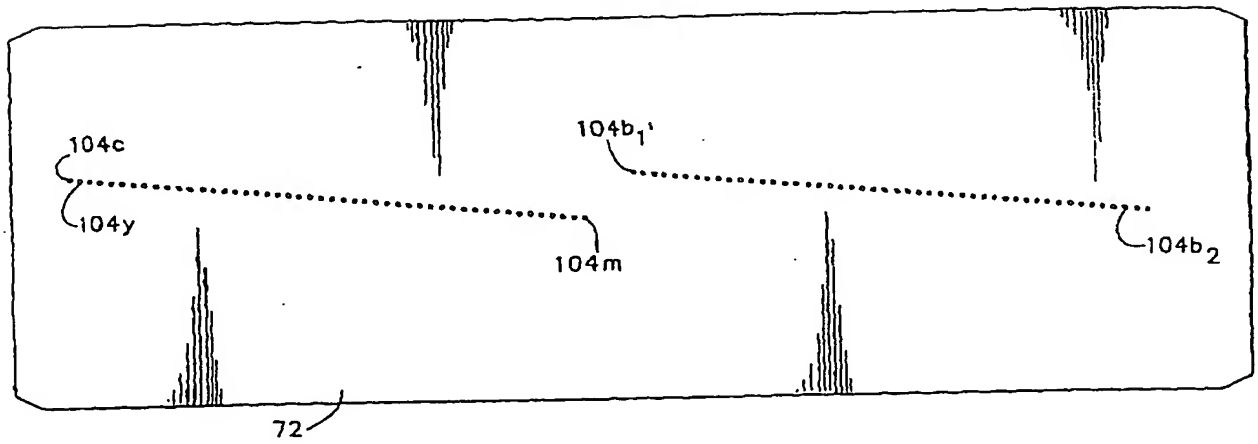
【第１５図】


130c'
130m'
130y'
71b1'
130b1'
130b2'
71c
71y
154
130c
71m
71b2
130y
12y
130m
12y'
130b1'
130b2
148
12m
70
156

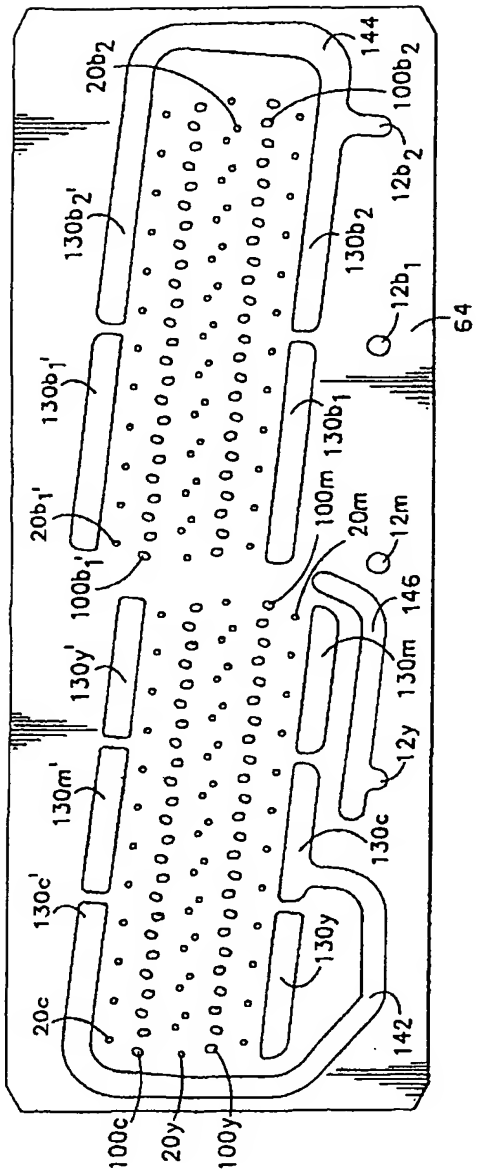
【第８Ｂ図】



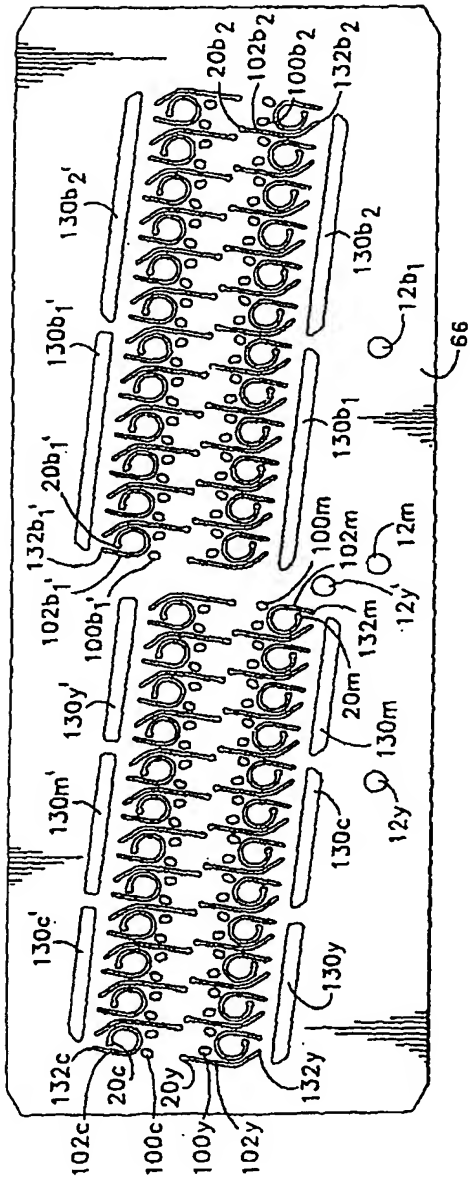
【第１６図】



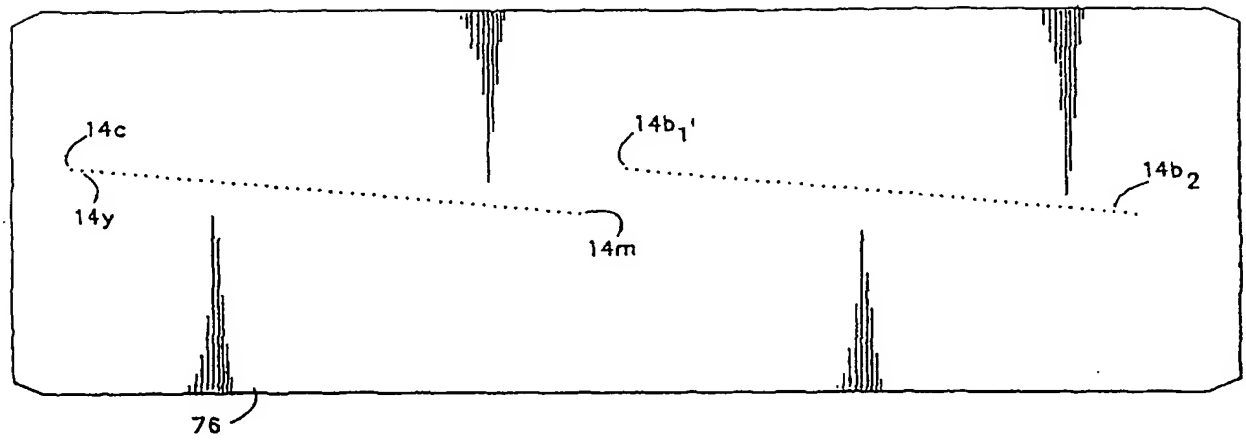
【第１２図】


144
20b2
100b2
12b2
130b2'
130b2
12b1
64
130b1'
130b1
20b1'
100b1'
100m
20m
12m
146
130y'
130m
12y
130m'
130c
130c'
130y
20c
142
100c
20y
100y

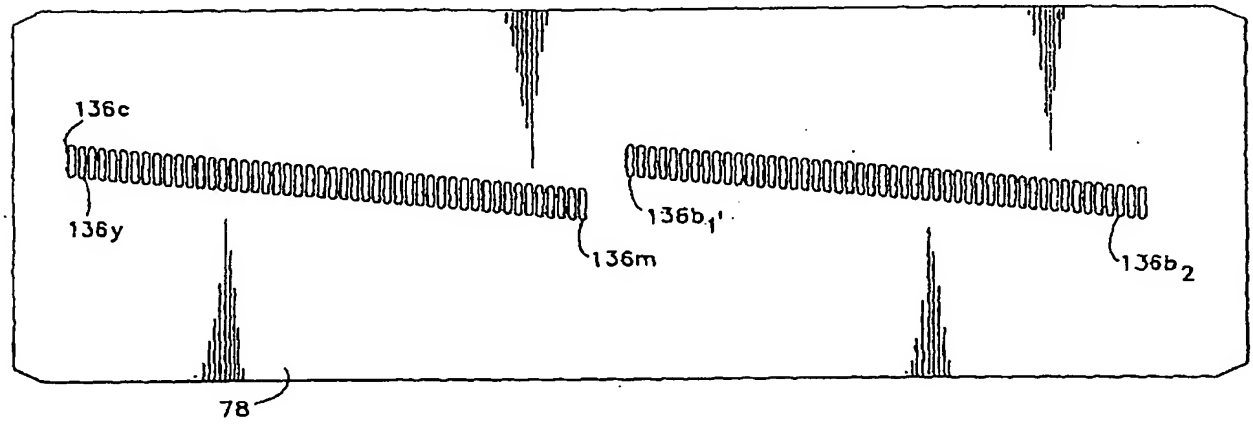
【第１３図】


20b2
102b2
100b2
132b2
130b2'
130b2
12b1
66
130b1'
130b1
132b1'
20b1'
102b1'
100b1'
100m
102m
12m
12y'
130y'
132m
20m
130m
130m'
130c
12y
130c'
130y
132c
20c
20y
132y
102c
100c
100y
102y

【第17図】



【第18図】



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特公 昭63－40672（ＪＰ，Ｂ２）

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CLAIMS

[Claim(s)]
[Claim 1] It is the drop on-demand mold ink jet print head of the multi-nozzle which receives ink from an ink source of supply, answers each ink driving means combined with each nozzle, and injects an ink droplet toward a print medium. It is held mutually and has two or more plates which form the above-mentioned ink jet print head. The 1st plate of these two or more plates has at least two or more nozzles which became one train which an ink droplet passes for ink injection. The ink pressure room of two or more approximate circle forms is formed in the 2nd plate of two or more above-mentioned plates. The above-mentioned ink pressure room is arranged so that each geometrical hit alignment of this ink pressure room may come on one of the at least three trains not crossing. The geometrical hit alignment of the above-mentioned ink pressure room on the one above-mentioned train has shifted from the geometrical hit alignment of the above-mentioned ink pressure room on other trains which adjoined. Each of the above-mentioned ink pressure room has the ink outlet connected with the ink inlet port connected to the ink supply channel at the path. The above-mentioned ink inlet port and the above-mentioned ink outlet have separated into the both sides of the above-mentioned ink pressure room mutually. This ink to one of the nozzles to which ink was absorbed from the above-mentioned ink supply channel, and the 1st plate of the above related through the above-mentioned path Delivery, At least one path plate separates more the 1st plate of the above, and the 2nd plate of the above. Each of the above-mentioned nozzle is in abbreviation which connects, respectively by making it one piece to which the above-mentioned ink outlet relates, and the above-mentioned path plate has two or more paths of die length and a cross-section field. It has the above-mentioned ink driving means combined with each of the above-mentioned ink pressure room while the 3rd plate of two or more above-mentioned plates adjoined the 2nd plate of the above and having been arranged. the time of each of the above-mentioned nozzle having the similar resonance characteristic, and driving by the wave with the almost same above-mentioned ink driving means relevant to each of the above-mentioned nozzle -- each of the above-mentioned nozzle -- abbreviation -- the ink jet print head characterized by having the same injection property.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[Industrial Application]
This invention relates to the small ink jet print head which constituted the head, especially two or more ink jet nozzles driven separately respectively for printers in the shape of an array.
[Description of the Prior Art]
An ink jet system especially a drop mold on demand, or an impulse mold ink jet system is common knowledge from the former. The principle of impulse mold ink jet equipment is carrying out the variation rate of the ink room, and injecting an ink droplet from an ink room through a nozzle. A drive is used in order to carry out the variation rate of the ink room. The typical drive contains the converter like the piezoelectric device combined with the thin septum. If an electrical potential difference is impressed to this converter, although a converter tends to change plane magnitude, it will result in bending, since it has combined with the septum firmly. The ink of the ink interior of a room displaces by this converter bending, and while ink flows into an ink room from an ink feed hopper, ink is sent to a nozzle from an output. It is desirable to constitute a head generally, so that many nozzles can be arranged in the shape of [of high density] an array. However, preparing many ink rooms and connecting the nozzle of a large number corresponding to these ink rooms is not being able to do so simply. This is an especially big problem in the case of an array-like small ink jet print head. It relates to this and the conventional example of shoes is given.
In U.S. Pat. No. 4266232, such as Juliana Junior, and U.S. Pat. No. 4312010 of DORINGU, the nozzle was made to collect two or more channels prolonged from two or more ink pressure rooms, respectively, and the nozzle array of the high density which narrowed spacing of a nozzle is realized into the narrower section. if a nozzle is mounted in high density into such a narrowed section -- the thickness of a print head -- markedly -- alike -- increase -- a production process will become complicated. Furthermore, in the patent of DORINGU, the nozzle array which prepared the channel of the die length from which it differs for connecting the nozzle corresponding to an ink room, respectively is indicated. Since this kind of head prepares the channel of a large number from which die length differs, an ink injection property will change with nozzles. although it is also possible to control a piezoelectric transducer so that amendment to the channel from which the drive circuit attached at an expensive price is prepared, and die length differs may be carried out -- **** -- even if it prepares such a drive circuit, it is difficult to make a uniform ink droplet inject from the nozzle which has various properties.
In Fig. 20 of the U.S. Pat. No. 3747120 specification of a stem, the example of another ink jet print head is indicated. In this example of a design, the core was shifted and the circular ink pressure room of two trains, three trains, and two trains is arranged, respectively. Each ink pressure room is connected to the common ink room by the channel of different die length, respectively. The nozzle is connected to this common ink room, respectively. Thus, the fault at the time of preparing a common ink room between a nozzle group and a channel group is that an acoustical cross talk occurs between each nozzles.
In U.S. Pat. No. 4599628, such as DORINGU, furthermore it has a nozzle array, the ink jet print head of another structure is indicated. Each nozzle is connected to the common ink feeder by the ink pressure

room of approximate circle drill type in this example. These ink pressure rooms are formed in the parallel pressure room group mutually [two trains in which each has a circular cross section], and the ink pressure room center of group of one train and the pressure room center of group of the train of another side are arranged in in a straight line, respectively.
The ink jet print head of another configuration is indicated by U.S. Pat. No. 4680595, such as KURUTSU URIBE. Fig. 1 of this official report and Figs. 3 , 5 , and 6 divide the ink pressure room group of an abbreviation rectangle into the parallel group of two trains, and show the equipment which carried out alignment of those cores. The ink jet nozzle is connected to the ink pressure room which corresponds respectively. The medial axis of each nozzle is prolonged at right angles to a field including an ink pressure room, and intersects the extension of an ink pressure room. Moreover, ink is supplied to these pressure rooms through the ink hole carefully formed so that a location might have consistency with a nozzle hole, respectively. When making it operate generally by the same driver voltage which is a predetermined ink droplet injection rate using the ink which has specific viscosity, surface area becomes large rather than the case where the direction of a rectangular piezoelectric transducer is a round shape or a hexagon mold. Furthermore, with the structure of this conventional ink jet array, when including an ink room in the ink jet of a certain magnitude, a limit of magnitude arises.
U.S. Pat. No. 4460906 of the kana climax is indicating the ink jet print head which prepared the offset channel which connects a circular ink pressure room and a circular nozzle. With this print head, since ink is injected in the direction perpendicular to the field of an ink pressure room, ink ****** will arise on each nozzle outside front face which injects ink. Consequently, since ink other than the ink supplied from a corresponding ink pressure room is supplied to a nozzle, the same problem as the case of a patent of an above-mentioned stem arises.
The contents of U.S. Pat. No. 4216477, such as Mazda Motor, and Koto's U.S. Pat. No. 4525728 are the typical examples of the ink jet equipment which makes ink inject perpendicularly and in parallel to the field of an ink pressure room. Generally, the conventional equipment which makes ink inject in parallel with the field of an ink pressure room has the fault that manufacture becomes complicated comparatively. In the example of Koto's patent, the rectangle converter group of a single tier was prepared in one side face of a substrate, and the converter group of other single tiers is prepared in the opposite side face of a substrate. Since the location has shifted to the converter group of an opposite side face, and opening of a nozzle, the converter group of one side face of this substrate and opening of the nozzle corresponding to it are disadvantageous for high density assembly. The converter of each rectangle is combined with the ink room connected to the nozzle hole through the path in the example of patents, such as Mazda Motor. In the case of the example indicated by this patent specification, the die length of the ink path connected to the nozzle hole differs according to the physical relationship of each converter and the nozzle corresponding to it. In Figs. 3 and 4 of U.S. Pat. No. 4584590, such as Fish Bec, the ink jet print head of another format which injects an ink droplet in the direction parallel to the field of a rectangular converter, and expands and contracts the volume of an ink room is indicated.
Another example which injects an ink droplet parallel to the field of an ink pressure room is indicated by U.S. Pat. No. 4435721 of TSUZUKI, U.S. Pat. No. 4528575 of Mazda Motor, U.S. Pat. No. 4521788 of KAMURA, and U.S. Pat. No. 3427850 of YAMAMURO.
Thus, although there are many conventional examples about an ink jet print head, as compared with these conventional examples, it is still smaller, manufacture is easy, and it is important to realize an ink jet print head with high effectiveness possible [high-speed operation].
Therefore, the purpose of this invention is offering the small ink jet print head which two or more nozzles' were made to approach and was constituted in the shape of an array.
Another purpose of this invention is comparatively easy to manufacture, and is offering the ink jet print head which reduced the manufacturing cost.
Other purposes of this invention are offering the ink jet print head which can operate efficiently and stably at a high speed comparatively.
The purpose of further others of this invention is offering the ink jet print head whose ink droplet injection property of each nozzle is abbreviation identitas.

[Means for Solving the Problem]
The ink jet print head of this invention The nozzle plate in which two or more nozzles to have multilayer board structure and for these multilayer boards inject an ink droplet were formed, The pressure room plate which two or more ink pressure rooms of an approximate circle form were made to approach mutually, and carried out array formation at at least 2 trains, The ink path plate in which the path which connects the above-mentioned nozzle and the output of the above-mentioned ink pressure room corresponding to it, respectively was formed, It was joined to the 2nd plate of the above, and has the curtain board which separates the ink pressure room and driving means of the above-mentioned plurality, and the center position of each ink pressure room in ******** is shifted and arranged in the direction of a train to the center position of each ink pressure room within one train of a pressure room plate.
[Function]
By arranging efficiently the array of two or more ink pressure plates which influence the magnitude of the whole equipment, the ink jet print head of this invention is small, and has realized equipment with comparatively easy manufacture.
[Example]
First, the technique which will be the requisite is explained before explanation of the example of this invention. The opportunity of this invention is a request to the small drop on-demand ink jet print head which constituted two or more ink jet nozzles which each drives with the drive like a piezoelectric transducer in the shape of an array. I will consider the ink jet print head used for the printing equipment of a typewriter mold with which a print head prints on both directions by carrying out repetitive migration, and a print medium is perpendicularly sent out in a curved-surface top after that. In this case, a print head to which the die length of the perpendicular direction of a nozzle array is formed as small as possible, and dispersion in the distance from various nozzles to a print medium makes it as small as possible is desirable. This min vertical distance is equal to the inverse number of print linear density, and a number of a jet nozzle of products which print a specific color. For example, when printing by the consistency of 300 lines per inch by 48 nozzles which print black, the minimum vertical distance of the nozzle train becomes 47/300 inch.
Furthermore, it is desirable to also make the horizontal die length of a print head into min. Theoretically, as for the train of the perpendicular direction of 48 nozzles, in the case of black, level, and the head part printed perpendicularly, the die length to the core of the last nozzle becomes 47/300 inch from the core of the first nozzle about 300 lines per inch using 48 nozzles. It can print from the right end of paper (print medium) to a left end, without each nozzle carrying out excessive scan actuation in this configuration. If a nozzle is shifted horizontally and constituted, in order to print on all the fields on a print medium, only the shifted die length needs to take the margin of scan actuation, and it is necessary to scan it too much horizontally at least. By such excessive scan actuation, print time amount also turns long up and the width of face of the whole printer equipment will also become large. Therefore, in order to make width of face of equipment small, it is desirable to make horizontal spacing of a nozzle into min. Since the dimension of the longitudinal direction of a pressure transducer (a piezoelectric transducer and the septum at which it turns to the ink pressure interior of a room should put together) must be time [what] larger than the value of the inverse number of print linear density, it is necessary to shift a nozzle group somewhat horizontally, and it needs to arrange it. This die length to shift is decided by the dimension of a converter, and arrangement of a nozzle. Therefore, it is good to make this die length to shift into min.
The one approach of making horizontal spacing of a nozzle min is putting in no components in an ink pressure room or the boundary of the array of a pressure transducer. When it is in these pressure room or the same field as a converter, all other components are arranged on the outside of the array, or are arranged on the array (it is the upper location more nearly further than a nozzle group), or to the bottom (location near a nozzle group). For example, all the electrical installation to a converter can be prepared in the field of a pressure-transducer top, and all of another side, an inlet-port path, offset, a channel path, an output path, and a nozzle group can be prepared in an ink pressure room or the field of the pressure-

transducer bottom. If two kinds of elements in these are prepared in the same field, since it will become obstructive mutually, it arranges in a mutually different field. Consequently, a horizontal gap of a nozzle group is decided only by saying whether which makes two or more pressure transducers or ink pressure rooms approach, and they can be arranged. For example, an inlet-port path can be arranged in the field different from an offset channel path, and an offset channel path can be arranged in a different field from an outlet path. Therefore, what is necessary is to increase the thickness of a print head and just to make it multilayer structure, in order to make the perpendicular and horizontal dimension of a nozzle array into min.

The electronic drive circuit of IC configuration is cheaper than the case where a circuit is generally constructed from each components. It will become cheaper if the trigger of all the drive circuits in this IC can be carried out to the same moment. Therefore, when the nozzle group of a print head cannot be arranged perpendicularly at a single tier, the horizontal gap with one nozzle and the next nozzle will serve as an integral multiple of the inverse number of horizontal print linear density, if a cheap drive circuit is used.

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In U.S. Pat. No. 4266232, such as Juliana Junior, and U.S. Pat. No. 4312010 of DORINGU, the nozzle was made to collect two or more channels prolonged from two or more ink pressure rooms, respectively, and the nozzle array of the high density which narrowed spacing of a nozzle is realized into the narrower section. if a nozzle is mounted in high density into such a narrowed section -- the thickness of a print head -- markedly -- alike -- increase -- a production process will become complicated. Furthermore, in the patent of DORINGU, the nozzle array which prepared the channel of the die length from which it differs for connecting the nozzle corresponding to an ink room, respectively is indicated. Since this kind of head prepares the channel of a large number from which die length differs, an ink injection property will change with nozzles. although it is also possible to control a piezoelectric transducer so that amendment to the channel from which the drive circuit attached at an expensive price is prepared, and die length differs may be carried out -- **** -- even if it prepares such a drive circuit, it is difficult to make a uniform ink droplet inject from the nozzle which has various properties.
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Therefore, the purpose of this invention is offering the small ink jet print head which two or more nozzles' were made to approach and was constituted in the shape of an array.
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[Means for Solving the Problem]
The ink jet print head of this invention The nozzle plate in which two or more nozzles to have multilayer board structure and for these multilayer boards inject an ink droplet were formed, The pressure room plate which two or more ink pressure rooms of an approximate circle form were made to approach mutually, and carried out array formation at at least 2 trains, The ink path plate in which the path which connects the above-mentioned nozzle and the output of the above-mentioned ink pressure room corresponding to it, respectively was formed, It was joined to the 2nd plate of the above, and has the curtain board which separates the ink pressure room and driving means of the above-mentioned plurality, and the center position of each ink pressure room in ******** is shifted and arranged in the direction of a train to the center position of each ink pressure room within one train of a pressure room plate.
[Function]
By arranging efficiently the array of two or more ink pressure plates which influence the magnitude of the whole equipment, the ink jet print head of this invention is small, and has realized equipment with comparatively easy manufacture.
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First, the technique which will be the requisite is explained before explanation of the example of this invention. The opportunity of this invention is a request to the small drop on-demand ink jet print head which constituted two or more ink jet nozzles which each drives with the drive like a piezoelectric transducer in the shape of an array. I will consider the ink jet print head used for the printing equipment of a typewriter mold with which a print head prints on both directions by carrying out repetitive migration, and a print medium is perpendicularly sent out in a curved-surface top after that. In this case, a print head to which the die length of the perpendicular direction of a nozzle array is formed as small as possible, and dispersion in the distance from various nozzles to a print medium makes it as small as possible is desirable. This min vertical distance is equal to the inverse number of print linear density, and a number of a jet nozzle of products which print a specific color. For example, when printing by the consistency of 300 lines per inch by 48 nozzles which print black, the minimum vertical distance of the nozzle train becomes 47/300 inch.
Furthermore, it is desirable to also make the horizontal die length of a print head into min. Theoretically, as for the train of the perpendicular direction of 48 nozzles, in the case of black, level, and the head part printed perpendicularly, the die length to the core of the last nozzle becomes 47/300 inch from the core of the first nozzle about 300 lines per inch using 48 nozzles. It can print from the right end of paper (print medium) to a left end, without each nozzle carrying out excessive scan actuation in this configuration. If a nozzle is shifted horizontally and constituted, in order to print on all the fields on a print medium, only the shifted die length needs to take the margin of scan actuation, and it is necessary to scan it too much horizontally at least. By such excessive scan actuation, print time amount also turns long up and the width of face of the whole printer equipment will also become large. Therefore, in order to make width of face of equipment small, it is desirable to make horizontal spacing of a nozzle into min. Since the dimension of the longitudinal direction of a pressure transducer (a piezoelectric transducer and the septum at which it turns to the ink pressure interior of a room should put together) must be time [what] larger than the value of the inverse number of print linear density, it is necessary to shift a nozzle group somewhat horizontally, and it needs to arrange it. This die length to shift is decided by the dimension of a converter, and arrangement of a nozzle. Therefore, it is good to make this die length to shift into min.
The one approach of making horizontal spacing of a nozzle min is putting in no components in an ink pressure room or the boundary of the array of a pressure transducer. When it is in these pressure room or the same field as a converter, all other components are arranged on the outside of the array, or are arranged on the array (it is the upper location more nearly further than a nozzle group), or to the bottom (location near a nozzle group). For example, all the electrical installation to a converter can be prepared in the field of a pressure-transducer top, and all of another side, an inlet-port path, offset, a channel path, an output path, and a nozzle group can be prepared in an ink pressure room or the field of the pressure-

transducer bottom. If two kinds of elements in these are prepared in the same field, since it will become obstructive mutually, it arranges in a mutually different field. Consequently, a horizontal gap of a nozzle group is decided only by saying whether which makes two or more pressure transducers or ink pressure rooms approach, and they can be arranged. For example, an inlet-port path can be arranged in the field different from an offset channel path, and an offset channel path can be arranged in a different field from an outlet path. Therefore, what is necessary is to increase the thickness of a print head and just to make it multilayer structure, in order to make the perpendicular and horizontal dimension of a nozzle array into min.

The electronic drive circuit of IC configuration is cheaper than the case where a circuit is generally constructed from each components. It will become cheaper if the trigger of all the drive circuits in this IC can be carried out to the same moment. Therefore, when the nozzle group of a print head cannot be arranged perpendicularly at a single tier, the horizontal gap with one nozzle and the next nozzle will serve as an integral multiple of the inverse number of horizontal print linear density, if a cheap drive circuit is used. Although this requirement is eased when two or more drive circuits are used, horizontal spacing of all the nozzle groups driven by one IC becomes the integral multiple of the inverse number of horizontal print linear density.

Moreover, the actuation which makes driver voltage a low battery and injects an ink droplet at a high speed is possible, assembly is comparatively easy, and it is desirable to realize the small print head which can print multicolor ink. Generally, the print head having all of these descriptions is the most desirable. But each of each of these descriptions is desirable, and has contributed separately as a description of the ink jet print head of this invention.

Fig. 2 is one example of the ink jet print head of this invention, and the ink inlet port 12 to which ink is supplied is formed in the head body 10. The ink style path from the output 14 which forms an ink droplet further, i.e., a nozzle, and the ink inlet port 12 to a nozzle 14 is formed in the head body 10. Generally, including the nozzle array 14 by which the print head of this invention was constituted from many nozzles, these nozzles approach mutually, are arranged and are printed on a print medium (not shown) by the ink droplet injected from each nozzle.

The ink included in the ink inlet port 12 flows into the ink supply manifold 16. A typical ink jet print head has at least four manifolds which receive black, cyanogen, a Magenta, and yellow, respectively, and these are used for the print of black and subtractive primaries. However, the number of manifolds is printed by the design of a printer, for example, a black chisel, is printed in full color fewer colors, or can be changed according to a thing case. Ink passes through the ink supply channel 18 and the ink inlet port 20 from the ink supply manifold 16, and it flows into the ink pressure room 22. Ink flows out of the ink pressure room 22 through an outlet 24, and is supplied to the nozzle 14 which an ink droplet injects through the ink path 26. The arrow 28 shows the flow of ink.

As for the ink pressure room 22, one side face is formed by the flexible septum 34. The pressure transducer of this example is the piezo-electric ceramic disk 36 which fixed with the epoxy resin to the septum 34, and is stuck on the ink pressure room 22. As usual, although the piezo-electric ceramic disk 36 is not illustrated, it has the metal membrane layer 38 electrically connected to the electronic drive circuit. Although the pressure transducer of other configurations may be used, the pressure transducer of Fig. 2 operates in bending mode. That is, if an electrical potential difference is impressed to a piezo-electric ceramic disk, a disk tends to change magnitude. However, since the disk has fixed firmly to the septum, it brings a straight result. A variation rate arises in the ink in the ink pressure room 22 by this bending, ink flows outward through a path 26, and a nozzle 14 is supplied. After injection of an ink droplet, regrouting of the ink to the ink pressure room 22 is performed, when a pressure transducer 36 bends to the opposite side.

In addition to the output-flow path of above-mentioned ink, the alternative ink outlet 42, i.e., a purge channel, is formed in the head body 10. This purge channel 42 is connected to the inside part of the head which adjoins a nozzle 14 with the ink path 26. The purge manifold 44 is connected by this purge channel 42 from the ink path 25, and it has connected with the purge output port 48 through the output path 46 from this purge manifold 44. This purge manifold 44 is usually connected to the ink path

corresponding to many nozzles by the purge channel 42 and the same channel. Although ink flows from the purge channel 42 to a manifold 44 and the purge path 46 as an arrow 50 shows during purge actuation (removal actuation of air bubbles etc.), for details, it mentions later.
In order to make easy manufacture of the ink jet head of this invention, it is suitable to form the head body 10 with a multilayer board or multilayer sheets, such as stainless steel material. These multilayer sheets or multilayer boards are constituted from the example of Fig. 2 by the following various plates. The curtain board 60 forms the septum 34, the ink inlet port 12, and the purge outlet 48. The ink pressure plate 62 forms a part of ink pressure room 22, ink supply manifold, and a part of purge path 48. The division plate 64 forms a part of purge path 46 in a part of inlet port 20 of a part of ink path 26, one interface of the ink pressure room 22, and an ink pressure room and outlet 24, ink supply manifold 16, and a list. The ink inlet-port plate 66 forms a part of a part of ink path 26, inlet-port channel 18, and purge path 46. Moreover, another division plate 68 forms a part of ink paths 26 and 46. The offset channel plate 70 forms the principal part (offset channel part) 71 of a path 26, and a part of purge manifold 44. The division plate 72 forms a part of path 26 and purge manifold 44. The outlet plate 74 forms a part of purge channel 42 and purge manifold 44. The nozzle plate 76 forms the array-like nozzle 14. The alternative guard plate 78 protects a nozzle plate 76, and prevents possibility that a nozzle plate will receive a scratch and the damages on other.
Rather than the illustrated example, various ink paths, manifolds, and ink pressure rooms may be formed using many or a small number of metal plates, and the ink jet print head of this invention may be realized. For example, many plates may be used instead of forming the ink pressure room 22 with one plate, as shown in Fig. 2 . Moreover, it is not necessary to form all the various devices in a composite plate. For example, when manufacturing by chemical etching processing, the photoresist patterns used as a template for metaled chemical etching may differ for every field of a metal plate. Therefore, as long as it gives a more concrete example, the pattern of an ink inlet-port path is given on one field of a metal sheet, and it may be made to give the pattern of a pressure room on the field of the another side. Therefore, it is possible by controlling etching carefully to include a separate ink inlet-port path and an ink pressure room in a common metal layer.
In order to make assembly cost into the minimum, it designs so that all the metal layers of the ink jet print head except a nozzle plate 76 can be manufactured using comparatively cheap phot conventional pattern processes and conventional etching process. A machining process or other metalworking processes are not required. A nozzle plate 76 is completed through the following various processes. That is, they are the minute electron discharge method of electroforming from sulfur-containing nickel **, and 300 series stainless steel material, perforation of 300 series stainless steel material, etc. The last two processings are used in relation to the phot pattern processing and etching processing of all devices except the nozzle of a nozzle plate. Another, suitable processing is forming the remaining device of this plate by opening the hole of a nozzle, and standard **** processing. The print head of this invention is designed so that the conditions of the alignment between metal layers may not become severe. That is, the usual tolerance maintainable by chemical etching processing is suitable.
a certain suitable approach that a mechanical bolting machine with the suitable various multilevel-metal layers which form the ink jet print head of this invention is used -- alignment -- and it is combined. The suitable approach for association between metal layers is indicated by U.S. Pat. No. 4883219 (it corresponds to Japanese Patent Application No. No. 226369 [one to]), such as Anderson. According to the approach indicated by this specification, various metal layers are plated with a metal in 1/thickness of 8 - 1/4 micrometer. This metal to plate carries out diffusion association at a metal layer and fitness, and fits soldering, and even when reliable plating is possible for it and it does not use stainless steel material on the stainless steel material of a head, it can be plated good to the metal which forms that head. For example, gold can be joined together and soldered can plate upwards easily on stainless steel and very good. Various metal layers are accumulated in order on the alignment equipment of easy 2 pins after plating processing. This alignment equipment functions also as a diffusion coupler. the following processings are performed on these **** top wooden-clogs components.
(a) Carry out diffusion association of the thermal strain of various metal layers in the temperature

requirement made into min, i.e., 400-500 degrees C.
(b) Remove a metal layer article from a diffusion coupler.
(c) Insert without cursing among a hydrogen ambient atmosphere and fixing in a furnace.
(d) Solder.
This joint process is performed in the state of sealing, and the bonding strength between components is strong, does not leave a height which plugs up a channel with a minute print head, does not make the device of each part of a print head distorted, and can realize a very high satisfaction level and the outstanding print head near 100% of abbreviation. It can be completed within [in 3 hours] from the beginning of a joint process to the last, being able to perform this production process using a standard gilding machine, a standard soldering furnace, and an easy diffusion coupler, and manufacturing many ink jet print heads. Furthermore, since the plated metal is very thin, and all diffuse almost in stainless steel, there is nothing of the metal layer plated on the occasion of a soldering process for which this metal gives an operation of chemical change, electrolysis, etc. to ink. Therefore, it is satisfactory even if it uses ink and the metal like copper which reacts easily at a joint process as a plated metal.
Including two or more piezo-electric ceramic disks made to metalize, the these piezo-electricity ceramic disk doubled the core on the corresponding ink pressure room 22 in Fig. 1, respectively so that it might be shown, and the electromechanical pressure translators 34 and 36 chosen as the ink jet print heads of this invention have fixed to the metal curtain board 60 with the epoxy resin. Fig. 1 is a decomposition perspective view of the various metal layers 60-78 used for the assembly of the nozzle array mold print head which has 16 jet nozzles. If this type-conversion machine is made into an approximate circle form, electromechanical effectiveness will become high most. the volume of the field of a piezo-electric ceramic component predetermined in this electromechanical effectiveness -- it relates to the variation rate. Therefore, effectiveness is higher than the thing of the rectangle mold in which the direction of this type-conversion machine operates in bending mode.
In order to manufacture a very small ink jet print head easily, as shown in Fig. 1, the various ink pressure rooms 22 are abbreviation flatness. That is, since the cross section is far larger compared with the depth, high pressure generates the pressure room 22 with the variation rate of the volume of a pressure room. Furthermore, all the ink pressure rooms of the print head of this invention are arranged suitable for the location of the same flat surface in an ink jet print head, or the same depth. However, this is not indispensable requirements. The location of this pressure room is decided in the field of the metal plate 62 of one or more sheets, as shown in Figs. 2 and 1.
In order to form a head in high density, the ink pressure room 22 arranges in parallel the field of at least 2 trains which shifted the geometrical hit alignment of each other. Moreover, these pressure room is mutually separated by very few sheet-like ingredients. Generally, although this sheet-like ingredient remains between pressure rooms, this is for raising the dependability of association between metal layers so that the leakage of ink may not take place between metal layers. As shown in Figs. 1 - 7 (Fig. 3 shows the configuration covering the various layers of Fig. 1 superficially, Fig. 4th [the] and 5 shows the 2nd example of this invention, Fig. 6 shows the 3rd example of this invention, and Fig. 7 is drawing having shown each part repeatedly) The suitable example includes the train of at least four parallel ink pressure rooms 22, and the core of these trains is located in the location [core / of the next train] shifted. Especially, at the circular pressure room of Fig. 1, the location of the train of four parallel pressure rooms is shifted, and if the core of each pressure room is connected in a straight line, the array of a hexagon will be formed. What is necessary is just to arrange it in the shape of a forward hexagon to make it the smallest structure, although the core of a pressure room is located in the shape of [of an inequality side hexagon] an array. This array may increase the number of the pressure room which extends to which direction at arbitration and is established in an ink jet print head, and nozzles. In order to make it operate efficiently generally, it is desirable to have direction-magnitude, such as abbreviation, in the direction of the cross section of a pressure room. Therefore, it is thought that the pressure room of an approximate circle form is very efficient. However, the pressure room of other structures which the cross section made the hexagon, for example is also substantially isotropic about the cross section, and it is thought that it is efficient. Although the pressure room of other structures can also be adopted,

direction-things, such as abbreviation, are desirable about the cross section.
Although the typical thickness of the piezo-electric ceramic disk 36 is 0.010 inches, it may be thinner than it or may be thick. Although it is the ideal which is made an approximate circle form according to a circular ink pressure room, if these disks form these disks in a hexagon, although it is small, required driver voltage will go up. Therefore, these disks can be cut off and made from a circular saw etc. from a big base material. Only 1/1000 inch only of numbers of the diameter of the inscribed circle of the piezo-electric ceramic disk 36 of these hexagons is usually smaller than the diameter of the corresponding pressure room 22, and the 1/thousands of inches diameter of the circumscribed circle of these disks is large. The typical thickness of the septum layer 60 is 0.004 inches.
As Fig. 2 was explained, it connects with the nozzle to which each pressure room corresponds by the ink path 26. Generally, each of these paths 26 consist of the 1st section 100 where only the 1st distance was perpendicularly prolonged in the corresponding pressure room 22, the 2nd (offset channel) section 71 where only the 2nd distance was prolonged in the 2nd direction parallel to the field of the pressure room 22, and the 3rd section 104 which extended in the direction of the nozzle which is perpendicular to the 2nd direction and corresponds. The location of the nozzle 14 of two or more trains is decided to make main spacing between nozzles narrower than main spacing between corresponding ink pressure rooms by the offset channel section 71 of a path 26.
The offset channel section 71 is the principal part of a path 26. Furthermore, it is arranged between the path 26 and the nozzle corresponding to the ink pressure room 22 and them in especially an offset channel section. As for a pressure room and the path 26 corresponding to a nozzle, it is desirable for die length and the magnitude of a cross section to be equal. therefore, the thing which each jet devices of all will have the same resonance characteristic, and it will drive by the same wave if the inlet-port channel of a pressure room assumes that die length and the magnitude of a cross section are the same -- the abbreviation from various nozzles -- it becomes possible to print in the same ink droplet injection property. Furthermore, since the offset channel section 71 is usually formed in the single common metal plate, if it pulls in the thickness of an ink jet print head, it can make weight and cost the minimum. In Figs. 1 - 8, and 15 (Fig. 8 shows the 4th example of this invention, and Fig. 15 shows a part of this example), the offset channel section 71 has connected between circulation spaces 100 and 104. If 0.135 inches of spacing of the center to center of the pressure room arranged to the hexagon become, the distance from the core of the end of an offset channel section to the core of the other end will be 0.116 inches. That is, the die length of the geometric property of an equilateral triangle to an offset channel section is the pitch of an ink pressure room. $\sqrt{3}/2$

It is equal to what carried out multiplication. Furthermore, although the width of face of the end which the offset channel 71 has next to a nozzle is 0.015 inches, the width of face of the other end is 0.024 inches. Of course, these values can be changed. For example, the width of face of the other end of this channel was examined in 0.020-0.036 inches, and the good result was obtained. Although the typical thickness of an offset channel is 0.20 inches, this thickness may form the same layer of two sheets in piles.
Again, Figs. 1 - 3 are referred to. a nozzle 14 -- the field of the metal watch 62, and the corresponding field of the ink pressure room 22 -- abbreviation -- it has a perpendicular medial axis. Furthermore, if the medial axis of these nozzles is extended until it intersects the metal watch 62, it has crossed and shifted to the corresponding ink pressure room. With the ink jet print head of Figs. 1 and 3 , the nozzle 14 is arranged at one train. Arranging linearly does not need to arrange this not necessarily linearly [********]. On the other hand, the ink pressure room 22 connected to these nozzles is arranged at four trains. Furthermore, the dimension beside a pressure room is arranged by 0.110 inches, and the hexagon array of these pressure room 22 is arranged at intervals of 0.135 inches. Therefore, these ink pressure room approaches only at intervals of a critical mass required for association of a metal layer, and is prepared. Although the diameter of a nozzle had the good range of 35-85 microns, it is not necessarily restricted to this range. Since diffusion of the ink droplet of a print medium is restricted in order to print 300 dots per unit inch by water color ink, as for the diameter of a nozzle, it is desirable to make it about

75 microns. In these examples, the suitable thickness of a nozzle plate is about 63-75 microns, i.e., 0.0025-0.0030 inches.
Furthermore, in the configuration top of Figs. 1 and 4, especially an offset channel, main spacing between the nozzles which can be set working is about 0.0335 inches. If the line of a nozzle is in the location which rotated only the include angle of arc tangents 1/10 from the horizontal position in the case of this spacing (refer to the 8th Fig.), the vertical distance between ****** nozzles will become 1/300 inch exactly, and corresponding level spacing will become 10/300 inch. In the case of spacing of the level and the perpendicular direction of these, the print head is set up so that it may print on horizontal and vertical both directions by the consistency of 300 dots per unit inch.
I will consider the ink jet print head which has the configuration of an above-mentioned ink pressure room and a nozzle. Moreover, the number of the level dots between h and a nozzle is assumed [the inverse number of a perpendicular print consistency] to be n for the inverse number of v and a level print consistency. In this case, if Fig. 7 is referred to and spacing of the train of C and a pressure room will be set [spacing between nozzles] to L for s and main spacing between pressure rooms, the following relational expression will be materialized.

$$s = \sqrt{v^2 + (nh)^2}$$

$$C = 4s = 4\sqrt{v^2 + (nh)^2}$$

$$s = (\sqrt{3}/2)\,C = 2\sqrt{3}\sqrt{v^2 + (nh)^2}$$

Furthermore, as a concrete example, if it is v=h=1 / 300 inches, as shown in the following tables, the value of s, C, and L will be chosen to the value of various n.

[表]

n	s(インチ)	C(インチ)	L(インチ)
10	.0335	.1340	.1160
9	.0302	.1207	.1046
8	.0269	.1075	.0931
7	.0236	.0943	.0816
6	.0203	.0811	.0702

Values other than this are calculable similarly. Moreover, the integral multiple of the inverse number of the level print consistency of level spacing between nozzles can apply the same count without limit.
In Fig. 7 , the ink inlet port 20 and the ink outlet 24 of the pressure room 22 are completely established [the pressure room] for 4 ****** in the opposite side. Only one train of a nozzle 14 is arranged along the center of an ink jet print head, and an ink supply manifold (refer to Fig. 1 and the 8th Fig.) is in the outside of the boundary of an ink pressure room array. Since the flow of the ink of a pressure room is good in the case of restoration of ink, and purge actuation, a bubble and an impurity are easily removed from the inside of ink by the inlet port and outlet which were established in these antipodes. Since the configuration of the inlet port of this ink and an outlet makes both distance max, acoustical degree of separation's improves certainly. Furthermore, an ink outlet becomes near by the nozzle rather than an ink inlet port, and ink becomes easy to flow.
Therefore, with the illustrated structure, the nozzle which corresponds at spacing made to approach further rather than spacing approached between pressure rooms may be arranged. For example, if main spacing of a pressure room is set to X, it is suitable for main spacing of the nozzle corresponding to this to make it the die length of the quadrant of X so that an above-mentioned example may show. As for spacing of the nozzle within the train same in order to make it a symmetrical configuration, it is desirable to consider as the inverse number of the number of the trains of the ink pressure room

corresponding to the nozzle train. It follows, for example, when the number of the trains of the ink pressure room corresponding to the nozzle of one train is 6, it is good to set main spacing of the nozzle of the train to 1/6 of main spacing of the train of an ink pressure room corresponding. Consequently, the very small ink jet print head which spacing of a nozzle was made to approach is realizable. When a more concrete example shows the point that the ink jet print head of this invention is small, the nozzle array containing 96 nozzles of Fig. 7 is about 0.07 inches in die length of about 3.8 inches, 1.3 inch of ****, and thickness.

Figs. 1 and 3 show the ink outlet channel 42 which connects the ink outlet manifold 44 of Fig. 2 to a nozzle 14, i.e., the channel for a purge. Usually, these channels and manifolds that were added further are only used only during the purge actuation period for the first Jet ink restoration actuation and cellular removal. Since a bulb (not shown) is used for closing the purge outlet 48, when not used, it does not flow for the purge style path 50. U.S. Pat. No. 4727378 by Li etc. is indicating the detailed structure of such a purge outlet. Generally, the path of ink is prepared out of the minute nozzle group 14 by the channel and manifold for a purge at each ink jet. Consequently, air bubbles and other impurities can be removed from an ink jet head, without passing a nozzle. These ink outlet channels and manifolds that were added did not produce at all effect which degrades the engine performance of the ink jet print head of this invention. Although the die length of a channel 42 is adjustable, for die length, 0.300 inches and width of face are [0.010 inches and the thickness of a suitable dimension] 0.004 inches. If the channel for a purge and an outlet are lost, since the metal plate of the print head for constituting these is removable, the thickness of the print head of this invention can be reduced.

The ink supply channel 18 is formed in the plate 66 between the ink pressure room 22 and an ink nozzle 14 in Figs. 1 thru/or 3 . It is assumed that an ink jet print head is the structure of having the ink pressure room of four trains. In this case, in order to make it the ink feed hopper of two trains inside a pressure room not let between the pressure rooms of two trains of the outside of an ink jet pass, it will be necessary to increase spacing between pressure rooms, and an ink feed hopper will be connected with the pressure room of the plate located in the ink pressure room bottom. That is, the ink feed hopper is prolonged into the plate between a pressure room and a nozzle from the outside of an ink jet head. These ink feed hopper is prepared so that a location may be in agreement with a pressure room, respectively, and it is connected to the pressure room from the pressure room bottom.

In order to make fluid impedance of the inlet-port channel of the pressure room of an inside train equal to the fluid impedance of the inlet-port channel of the pressure room of an outside train, these channels can be made from two different structures which has the same cross section and the same die length. That is, please care about the structure of 102a and 102b of Fig. 1 and Figs. 3 , 8, and 13. The characteristic impedance to a fluid is decided by the die length and those cross-sectional area of an inlet-port channel, and this is chosen so that the engine performance of a request of an ink jet head may be attained, and the need of making the inlet port 20 of a pressure room into the shape of a small hole or a nozzle is avoided. Die length of 0.275 inches, width of face of 0.010 inches, and the thickness of the dimension of a typical inlet-port channel are about 0.001-0.016 inches according to the viscosity of ink. In the case of water color ink, in the case of hot melt ink [about one to 15 centipoise, and], the viscosity of ink is about ten to 15 centipoise extent. An important thing is deciding the magnitude of an ink inlet port to be able to supply sufficient ink for making it operate with the full speed of a request of an ink jet print head, and to maintain the acoustical separation condition of an ink pressure room good here.

As for the manifold for inlet ports, and the manifold for outlets, it is desirable to arrange on the outside of the boundary of the pressure room of four trains. Furthermore, making the volume of ink into the minimum, the dimension of the cross section of these manifolds is optimized so that compliance to the extent that sufficient ink for a nozzle can be supplied when all the ink jet nozzles are driven to coincidence, and the interaction between jet nozzles is made to the minimum may be maintained. The dimension of the typical cross section of this manifold is 0.12x0.02 inches. If an outlet channel and an outlet manifold are lost, the ink jet print head of this invention can be further miniaturized by arranging the manifold for inlet ports between a pressure room and a nozzle in the same layer as the offset channel 71. This example is shown in Figs. 4 and 5 . the advantage of the structure of this latter -- the inlet-port

channel 18 of both the train inside a pressure room, and an outside train -- it is good by the same structure, i.e., the same cross section, and the same die length. If an outlet channel is lost, it will enable a layer 72 to support a thin nozzle layer further firmly. In the bottom of the train of the outside of a pressure room, if an inlet-port manifold is arranged completely, the array of the same hexagon as the pressure room of the first four trains can be extended, and the train of further many pressure rooms can be prepared. That is, it becomes possible to form the pressure room of further many numbers into a layer 62. This example is shown in Fig. 6 at the detail. Furthermore, Figs. 9 - 18 are drawings showing the structure of the suitable various layers for the ink jet print head shown in Fig. 8.

Although ink is supplied to two or more ink supply channels from each manifold, according to the design of this invention, between the ink pressure room connected to the common manifold is separated acoustically. That is, in above-mentioned structure, an ink supply manifold and an ink supply channel function as an acoustical RC circuit substantially, and attenuate a pressure pulse. It generates at an ink pressure room, and such a pressure pulse goes back from the pressure room to a common manifold through an inlet-port channel, can go into the inlet-port channel of the next door of a manifold, and has a possibility of having a bad influence to the next jet nozzle. In this invention, since the effectiveness of compliance is acquired by these manifolds and the acoustical separation effectiveness is further acquired by the inlet-port channel, these pressure rooms are separated acoustically mutually. Dissociating acoustically means not being influenced by actuation of other jet nozzles by which the ink injection property of one jet nozzle was connected to the same manifold at all. It was observed that the injection period of an ink droplet is attained in 10 or less microseconds, and this acoustical separation was usually attained with the period of less than 3 microseconds. In a cross talk of this level, a print result is not affected at all.

In order to follow more the path of the ink style of the ink jet print head of this invention to accuracy, it explains with reference to Figs. 1 and 3 .

Ink is supplied to the ink manifold 130 (layers 62 and 64) through the ink inlet port 12 (layer 60). The ink from a manifold 130 is supplied to one inlet-port 132a of inlet-port channel 102a (layer 66). The ink from inlet-port channel 102a is sent to pressure room 22a (layer 62) through inlet-port 20a (layers 66 and 64) of a pressure room. According to an ink droplet injection pulse or purge actuation, ink flows to nozzle 14a (layer 76) through connecting path 100a (layers 64, 66, and 68) from pressure room 22a, offset channel 71a (layer 70), and path 104a (layers 72 and 74). Opening 136a of a guard plate 78 is prepared according to the location of nozzle 14a, and is larger than nozzle 14a. During purge actuation, the great portion of ink which reached ink path 104a is sent from a nozzle through purge channel 42a to path 138a (layers 74 and 72). These paths are expanded as illustrated, and they are connected to the manifold 44 for a purge. Ink is outputted through the outlet 46 (layers 68-60) for a purge from the manifold 44 for a purge.

Similarly, ink flows from a manifold 130 to inlet-port 132b (layer 66) of one manifold of inlet-port channel 102b, and the ink from inlet-port channel 120b is supplied to pressure room 22b through pressure room entrance 20b (layers 66 and 64). The ink from pressure room 22b is sent to nozzle 14b (layer 76) through connecting path 100b (layers 64, 66, and 68), offset channel 71b (layer 70), and path 104b (layers 72 and 74). The ink droplet from nozzle 14b is injected through opening 136b prepared in the guard plate 78. The great portion of ink which reached during purge actuation at path 104b is sent to the manifold 44 for a purge from path 138b (layers 74 and 72) through purge channel 42b. The ink from this manifold 44 flows out of a print head through the purge outlet 46 as mentioned above.

In the ink jet print head of Fig. 1, the manifold 44 for an ink purge of a top and the bottom and 44' are in the ink supply manifold 130 and 130' list of the bottom and the bottom. He can understand the ink style path to the remaining nozzles easily from above-mentioned explanation. Although used for usually printing black ink, the ink jet print head of Fig. 1 is usable although the ink of two colors is printed, in that case, supplies one color ink to manifold 130' of Fig. 1 top, and should just supply the color ink of another side to the lower manifold 130.

Similarly, I will follow the ink style path of Figs. 4 and 5 . The same reference mark is given to the element of these drawings corresponding to each element of Fig. 1 for convenience of explanation. In

Figs. 4 and 5 , ink flows to the manifold 130 of a layer 70 from the ink inlet port 12 (layers 60, 62, 64, 66, and 68). Same inlet-port 12' is prolonged in upper ink manifold 130' from these layers. The ink from a manifold 130 is supplied to the end of ink inlet-port channel 102a through path 132a (layers 66 and 68). The ink from channel 102a is supplied to the ink inlet port of the lower limit of pressure room 22a through path 20a (layers 66 and 64). The ink from the upper limit of pressure room 22a is supplied to the lower limit of a offset 71a of a layer 70 through path 100a (layers 64, 66, and 68). The ink from the upper limit of this offset channel is sent to nozzle 14a (layer 76) through path 104a (layer 72). Opening 136a of a guard plate 78 is prepared according to the location so that output, i.e., nozzle, 14a may be surrounded.

The ink style path to nozzle 14b which corresponds from the ink style path of going to ink pressure room 22b, and this ink pressure room 22b is the same as an above-mentioned ink style path. Therefore, the element of this ink style path gives suffix b to the same reference number as the element with which a **** corresponds, and the explanation beyond this is omitted. The print head of Fig. 4 is used for the print of the ink of a single color (for example, black) or two colors like 1st [**] Fig. ink jet print head. Furthermore, in the example of Fig. 4, the manifold for a purge and the purge channel are removed as mentioned above.

Fig. 6 is a decomposition perspective view of the ink jet print head which extends this invention and is obtained easily. Although this print head has further many manifolds for more color ink, contiguity spacing of the pressure room 22 and an ink jet nozzle is held.

Ink is supplied to each of the manifold 130 prepared in the layer 70, 130', 130", and 130** through an inlet port 12, 12'12", and 12**, respectively. Although these four manifolds support black, cyanogen, a Magenta, and yellow, respectively, such sequence is good anyhow. It will not be necessary to explain further, since the detail of the ink style path about these various ink pressure rooms is the same with having explained Fig. 4. However, the ink style path of the element relevant to the pressure rooms 22a and 22b which attached the reference mark corresponding to the reference mark of Fig. 4 is illustrated for convenience.

The ink jet print head of Fig. 8 is used for the both-way printing device similar to a typewriter. This device can carry out a full color print to horizontal and vertical both directions by the print consistency of 300 dots per inch. It was checked that the actuation which can trust this print head to the rate which prints about 11000 ink droplets in 1 second per nozzle is maintained. It has the train of 48 nozzles used for printing the ink jet print head black ink of Fig. 8. It also has the train of 48 nozzles used for this print head printing color ink further, and it separates into black ink with a train, and this train is prepared in the location horizontally shifted. 16 nozzles in 48 nozzles for these colors are the objects for cyanogen ink, and are other objects for 16 Magentas, and the 16 remaining pieces are the objects for yellow.

The layout of the print head of Fig. 8 can be easily changed into the nozzle configuration of one train instead of two trains. Even if the operating characteristic of this ink jet print head makes this change, it is not influenced at all.

Figs. 9 thru/or 18 are drawings of each part for the ink jet print head which has 96 nozzles of Fig. 8. The spacer plate 59 with which Fig. 9 equips with a converter, and Fig. 10 A curtain board 60 and Fig. 11 the ink pressure room plate 62 and Fig. 12 a division plate 64 and Fig. 13 -- a division plate 72 and Fig. 17 show a nozzle or the output dead plate 76, and, as for the division plate 68 and Fig. 15, Fig. 18 shows the guard plate 78 for the ink inlet-port plate 66 and Fig. 14, respectively, as for the offset channel plate 70 and Fig. 16. This print head of Fig. 8 is designed so that it may have the ink receptacle manifold of a large number which receive various color ink. In the illustrated example, it has a five-set manifold and two manifold sections are included for every set. Since these manifold sets are separated mutually, this ink jet print head can receive five kinds of color ink. It can follow, for example, this ink jet print head can receive the black ink for the ink of the cyanogen Magenta for a full color print, and the subtractive color mixture of yellow in three primary colors, and the print of a text. The 5th color which mixed and made cyanogen, a Magenta, and yellow on the print medium as 5th color ink may be used. Moreover, since black ink is usually used in case it prints a text and a graphic form, you may make it supply black ink to two or more manifold sets. [than color ink] [more] This concrete application is explained

below. Furthermore, distance between the corresponding nozzles to which ink is supplied from each manifold section and manifold section can be made into min by establishing two or more manifold sections in each color ink. In case this meets horizontally for example, during a print and an ink jet print head goes, dynamic change of the ink pressure generated by accelerating and slowing down an ink droplet can be controlled to min.

The various layers which constitute the example of Fig. 8 of this invention are explained with reference to Figs. 9 thru/or 18 about the path of the flowing ink.

Fig. 9 shows the spacer plate 59 which has the opening 140 equipped with the piezo-electric ceramic converter 36 of Fig. 8. This spacer plate 59 is arbitration components, serves as an outside front face of a piezo-electric ceramic crystal, and coplane relation, and makes the backside of an ink jet print head a plane. Two or more ink feed hoppers for supplying ink to a print head are prepared so that this layer 59 may be penetrated. These ink feed hoppers are shown by the reference mark of 12c (c shows the feed hopper of the color ink of cyanogen), 12y (y shows yellow), 12m (m shows a Magenta), 12b1 (b1 shows the 1st black ink), and 12b2 (b2 shows the 2nd black ink). For convenience, in the following explanation, c, y, m, b1, and b2 are used in order to show the components relevant to the path for which each ink of cyanogen, yellow, a Magenta, the 1st black, and the 2nd black flows, respectively. Please care about that there is no need of supplying the color ink of these versatility to an ink jet print head in the sequence indicated here. However, the ink jet PU head shown in Figs. 8 - 18 has 48 nozzle groups for the color print of the section on the left-hand side of a print head, and 48 nozzle groups for the black print of the right-hand side section of a print head so that it may mention later.

In the septum 60 of Fig. 10, ink feed hopper 12c-12b2 have penetrated this layer 60, respectively. Feed hopper 12c of cyanogen is connected to the cyanogen ink supply channel 142 which leads to two cyanogen manifold section 130c and 130c' in Fig. 11. Manifold section 130c is prepared so that the central part of the outside bottom of the left-hand side array of the pressure room 22 may be adjoined. Manifold section 130c' adjoins the part at the upper left of the left-hand side array of a pressure room, and is arranged. Furthermore, the ink feed hopper 12b2 of this layer 62 leads to the channel 144 connected to the black ink manifold section 130b2 and 130b2'. The manifold section 130b2 adjoins the lower right part of the right-hand side array of the pressure room 22, and is prepared, and manifold section 130b2' adjoins the upper right part of the right-hand side array of the pressure room 22, and is prepared.

Yellow ink feed hopper 12y leads to the channel 146 of a layer 62. In addition, connection of the Yellow ink to Yellow ink manifold section 130y and 130y' of Fig. 11 is made in another layer. Moreover, 12m of Magenta ink feed hoppers and the 1st black ink feed hopper 12b1 have penetrated this layer 62. These ink feed hoppers are connected to the Magenta and the black ink manifold, i.e., the part shown in Fig. 11 by 130m, 130m', 130b1, and 130b1', in other layers of a print head, respectively. Not ten pieces but required ink supply number of connections requires [whether it is small and] only five pieces by preparing a communication channel as shown by the number of 142, 144, and 146 between the separated manifold sections. Furthermore, by preparing a manifold ranging over two or more layers, it can be made to be able to increase, the depth, i.e., the volume, of a manifold, and, thereby, acoustical compliance can be improved.

As shown in Fig. 12, according to the location of the manifold of the layer 62 of Fig. 11, and a communication channel, the same manifold and communication channel of a layer 64 are arranged. Similarly, in the layer 66 of Fig. 13, since the part of an ink supply manifold has attained to even the layer 66, the acoustical compliance of a manifold is increased further. Moreover, the layer 66 also contains path 12y and 12y'. These paths lead to the edge of the communication channel 146 of the layers 62 and 64 of Figs. 11 and 12. Moreover, the increment in the volume of these manifolds and the increment in acoustical compliance are restricted by this layer 66.

In Fig. 14 and 15 Fig., it connects with the communication channel 148 and 12m of Magenta ink feed hoppers is connected to Magenta manifold section 130m and 130m' through this channel. Furthermore, Yellow ink feed hopper 12y is connected to manifold section 130y (Fig. 14) through the channel 150. Moreover, ink feed hopper 12y' is connected to Yellow ink manifold section 130y' (Fig. 15) through the

channel 154. Furthermore, it connects with layers 68 and 70 (14th [the] and 15 Figs.) through a path 156, and the black ink feed hopper 12b1 leads to the black ink manifold section 130b1 and 130b2 through this path further.
Therefore, ink is supplied to each ink manifold section by the above-mentioned approach. Moreover, the volume of each manifold section is increasing by preparing the part of a manifold section ranging over a multilayer field.
The path supplied to the black as which ink was chosen from these manifold sections, cyanogen, a Magenta and the ink pressure room 22b1 of yellow, 22b2, and 22c, 22m and 22y is explained further. Moreover, the path of the ink style from these ink pressure rooms to the nozzle corresponding to them is also explained. He can also understand easily the ink style path to other pressure rooms and nozzles.
[explanation / this]
In Figs. 13 and 14, the ink from cyanogen ink manifold section 130c' flows to ink feed hopper 132of ink supply channel 102c c. The ink from channel 102c is supplied to the upper part of ink pressure room 22c (layer 62 of Fig. 11) through feed hopper 20c (Fig. 12 and layers 64 and 66 of 13 Fig.) of an ink pressure room. Ink flows through pressure room 22c to path 100c (layers 64, 66, and 68 of 12th, 13, and 14 Fig.), and flows to offset channel 71c (layer 70 of Fig. 15) further. It flows to nozzle 14c (layer 76 of Fig. 17) to which ink corresponds through opening 104c (layer 72 of Fig. 16) from the lower limit section of offset channel 71c. This nozzle 14c is prepared in the covering protective layer 78 (Fig. 18) according to the location of opening 136c.
Similarly, the ink from Yellow ink manifold section 130y (Fig. 14) flows to inlet-port 132of ink supply channel 102y y (Fig. 13). The ink from ink supply channel 102y is supplied to the upper part of ink pressure room 22y through path 20y (layers 66 and 64 of the 13th and 12 Fig.). The ink from the lower part of this ink pressure room flows through path 100y (layers 64, 66, and 68 of 12th, 13, and 14 Fig.) in the lower limit section of the offset channel 71 (layer 70 of Fig. 15). The ink from the upper limit section of this offset channel flows to nozzle 14y (layer 76 of Fig. 17) through opening 104y (layer 72 of Fig. 16). Opening 136y of a protective layer 78 has lapped with nozzle opening 14y. Similarly, the suffixes m, b1, and b2 which correspond, respectively are given to the reference number of the element relevant to the path of ink of frequenting ink pressure room 22m, 22b1, and 22b2.
In Figs. 8, 15, and 17, black ink is supplied to 48 offset channels of the right-hand side array of Fig. 15 by arrangement of an above-mentioned manifold along with 48 nozzles contained in the right-hand side train of the nozzle of the plate 46 of Fig. 17. Furthermore, cyanogen ink is supplied to the first eight offset channels of the train of the offset channel array top on the left-hand side of Fig. 15, Magenta ink is supplied to the eight next offset channel, and Yellow ink is supplied to eight offset channels of the same train and also the 3rd group. Furthermore, Yellow ink is supplied to the first eight offset channels of the bottom train of a left-hand side offset channel array, cyanogen ink is supplied to the following eight offset channels, and Magenta ink is supplied to the following eight offset array. Thus, by constituting the train of the upper and lower sides of the offset channel of Fig. 15 from an interleave method, the color ink assigned to the nozzle of the print head of Fig. 17 which has this structure by the interleave method is supplied. That is, the ink of a different color is supplied to ****** each nozzle in the perpendicular direction of the nozzle group of the train on the left-hand side of Fig. 17. By this configuration, since the vertical separation of the nozzle of the ink of a certain color separates by at least 2 dots, color printing becomes easy. By adopting arrangement of such a manifold, and the ink supply approach, it is possible to change easily the array of the color supplied to a nozzle by the interleave method by request.
Thus, the example of this invention of Fig. 8 is small, manufacture is easy, and the ink jet print head which has the function which was excellent in versatility is realized.
Although the suitable example of this invention was explained above, it is clear to this contractor that various deformation and modification can be carried out if needed, without not limiting this invention only to the example explained here, and deviating from the summary of this invention.
[Effect of the Invention]
According to this invention, the ink pressure room has been arranged and the geometrical hit alignment of the ink pressure room on one train has shifted from the geometrical hit alignment of the ink pressure

room on other trains which adjoined so that each geometrical hit alignment of the circular ink pressure room to each of two or more nozzles arranged at one train may come on one of the at least three trains not crossing. Therefore, two or more nozzles arranged at one train can be made to approach. Moreover, from the case where it only arranges in the shape of a matrix tidily, the dimension of a direction perpendicular to the train of an ink pressure room can be made small, and very small ink jet print head equipment can be realized. Since the direction of the train of these ink pressure room can be adjusted to arbitration, the dimension of the directions of arbitration, such as a perpendicular, a horizontal, or the inclination direction, can be made small by request. Furthermore, the driving means which drives the ink of these ink pressure rooms can also be efficiently arranged corresponding to arrangement of an ink pressure room. Moreover, since the whole head is multilayer board structure, manufacture is easy.

[Translation done.]

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TECHNICAL FIELD

[Industrial Application]
This invention relates to the small ink jet print head which constituted the head, especially two or more ink jet nozzles driven separately respectively for printers in the shape of an array.

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EFFECT OF THE INVENTION

[Effect of the Invention]
According to this invention, the ink pressure room has been arranged and the geometrical hit alignment of the ink pressure room on one train has shifted from the geometrical hit alignment of the ink pressure room on other trains which adjoined so that each geometrical hit alignment of the circular ink pressure room to each of two or more nozzles arranged at one train may come on one of the at least three trains not crossing. Therefore, two or more nozzles arranged at one train can be made to approach. Moreover, from the case where it only arranges in the shape of a matrix tidily, the dimension of a direction perpendicular to the train of an ink pressure room can be made small, and very small ink jet print head equipment can be realized. Since the direction of the train of these ink pressure room can be adjusted to arbitration, the dimension of the directions of arbitration, such as a perpendicular, a horizontal, or the inclination direction, can be made small by request. Furthermore, the driving means which drives the ink of these ink pressure rooms can also be efficiently arranged corresponding to arrangement of an ink pressure room. Moreover, since the whole head is multilayer board structure, manufacture is easy.

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TECHNICAL PROBLEM

[Description of the Prior Art]
An ink jet system especially a drop mold on demand, or an impulse mold ink jet system is common knowledge from the former. The principle of impulse mold ink jet equipment is carrying out the variation rate of the ink room, and injecting an ink droplet from an ink room through a nozzle. A drive is used in order to carry out the variation rate of the ink room. The typical drive contains the converter like the piezoelectric device combined with the thin septum. If an electrical potential difference is impressed to this converter, although a converter tends to change plane magnitude, it will result in bending, since it has combined with the septum firmly. The ink of the ink interior of a room displaces by this converter bending, and while ink flows into an ink room from an ink feed hopper, ink is sent to a nozzle from an output. It is desirable to constitute a head generally, so that many nozzles can be arranged in the shape of [of high density] an array. However, preparing many ink rooms and connecting the nozzle of a large number corresponding to these ink rooms is not being able to do so simply. This is an especially big problem in the case of an array-like small ink jet print head. It relates to this and the conventional example of shoes is given.
In U.S. Pat. No. 4266232, such as Juliana Junior, and U.S. Pat. No. 4312010 of DORINGU, the nozzle was made to collect two or more channels prolonged from two or more ink pressure rooms, respectively, and the nozzle array of the high density which narrowed spacing of a nozzle is realized into the narrower section. if a nozzle is mounted in high density into such a narrowed section -- the thickness of a print head -- markedly -- alike -- increase -- a production process will become complicated. Furthermore, in the patent of DORINGU, the nozzle array which prepared the channel of the die length from which it differs for connecting the nozzle corresponding to an ink room, respectively is indicated. Since this kind of head prepares the channel of a large number from which die length differs, an ink injection property will change with nozzles. although it is also possible to control a piezoelectric transducer so that amendment to the channel from which the drive circuit attached at an expensive price is prepared, and die length differs may be carried out -- **** -- even if it prepares such a drive circuit, it is difficult to make a uniform ink droplet inject from the nozzle which has various properties.
In Fig. 20 of the U.S. Pat. No. 3747120 specification of a stem, the example of another ink jet print head is indicated. In this example of a design, the core was shifted and the circular ink pressure room of two trains, three trains, and two trains is arranged, respectively. Each ink pressure room is connected to the common ink room by the channel of different die length, respectively. The nozzle is connected to this common ink room, respectively. Thus, the fault at the time of preparing a common ink room between a nozzle group and a channel group is that an acoustical cross talk occurs between each nozzles.
In U.S. Pat. No. 4599628, such as DORINGU, furthermore it has a nozzle array, the ink jet print head of another structure is indicated. Each nozzle is connected to the common ink feeder by the ink pressure room of approximate circle drill type in this example. These ink pressure rooms are formed in the parallel pressure room group mutually [two trains in which each has a circular cross section], and the ink pressure room center of group of one train and the pressure room center of group of the train of another side are arranged in in a straight line, respectively.

The ink jet print head of another configuration is indicated by U.S. Pat. No. 4680595, such as KURUTSU URIBE. Fig. 1 of this official report and Figs. 3 , 5 , and 6 divide the ink pressure room group of an abbreviation rectangle into the parallel group of two trains, and show the equipment which carried out alignment of those cores. The ink jet nozzle is connected to the ink pressure room which corresponds respectively. The medial axis of each nozzle is prolonged at right angles to a field including an ink pressure room, and intersects the extension of an ink pressure room. Moreover, ink is supplied to these pressure rooms through the ink hole carefully formed so that a location might have consistency with a nozzle hole, respectively. When making it operate generally by the same driver voltage which is a predetermined ink droplet injection rate using the ink which has specific viscosity, surface area becomes large rather than the case where the direction of a rectangular piezoelectric transducer is a round shape or a hexagon mold. Furthermore, with the structure of this conventional ink jet array, when including an ink room in the ink jet of a certain magnitude, a limit of magnitude arises.

U.S. Pat. No. 4460906 of the kana climax is indicating the ink jet print head which prepared the offset channel which connects a circular ink pressure room and a circular nozzle. With this print head, since ink is injected in the direction perpendicular to the field of an ink pressure room, ink ****** will arise on each nozzle outside front face which injects ink. Consequently, since ink other than the ink supplied from a corresponding ink pressure room is supplied to a nozzle, the same problem as the case of a patent of an above-mentioned stem arises.

The contents of U.S. Pat. No. 4216477, such as Mazda Motor, and Koto's U.S. Pat. No. 4525728 are the typical examples of the ink jet equipment which makes ink inject perpendicularly and in parallel to the field of an ink pressure room. Generally, the conventional equipment which makes ink inject in parallel with the field of an ink pressure room has the fault that manufacture becomes complicated comparatively. In the example of Koto's patent, the rectangle converter group of a single tier was prepared in one side face of a substrate, and the converter group of other single tiers is prepared in the opposite side face of a substrate. Since the location has shifted to the converter group of an opposite side face, and opening of a nozzle, the converter group of one side face of this substrate and opening of the nozzle corresponding to it are disadvantageous for high density assembly. The converter of each rectangle is combined with the ink room connected to the nozzle hole through the path in the example of patents, such as Mazda Motor. In the case of the example indicated by this patent specification, the die length of the ink path connected to the nozzle hole differs according to the physical relationship of each converter and the nozzle corresponding to it. In Figs. 3 and 4 of U.S. Pat. No. 4584590, such as Fish Bec, the ink jet print head of another format which injects an ink droplet in the direction parallel to the field of a rectangular converter, and expands and contracts the volume of an ink room is indicated. Another example which injects an ink droplet parallel to the field of an ink pressure room is indicated by U.S. Pat. No. 4435721 of TSUZUKI, U.S. Pat. No. 4528575 of Mazda Motor, U.S. Pat. No. 4521788 of KAMURA, and U.S. Pat. No. 3427850 of YAMAMURO.

Thus, although there are many conventional examples about an ink jet print head, as compared with these conventional examples, it is still smaller, manufacture is easy, and it is important to realize an ink jet print head with high effectiveness possible [high-speed operation].

Therefore, the purpose of this invention is offering the small ink jet print head which two or more nozzles' were made to approach and was constituted in the shape of an array.

Another purpose of this invention is comparatively easy to manufacture, and is offering the ink jet print head which reduced the manufacturing cost.

Other purposes of this invention are offering the ink jet print head which can operate efficiently and stably at a high speed comparatively.

The purpose of further others of this invention is offering the ink jet print head whose ink droplet injection property of each nozzle is abbreviation identitas.

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MEANS

[Means for Solving the Problem]
The ink jet print head of this invention The nozzle plate in which two or more nozzles to have multilayer board structure and for these multilayer boards inject an ink droplet were formed, The pressure room plate which two or more ink pressure rooms of an approximate circle form were made to approach mutually, and carried out array formation at at least 2 trains, The ink path plate in which the path which connects the above-mentioned nozzle and the output of the above-mentioned ink pressure room corresponding to it, respectively was formed, It was joined to the 2nd plate of the above, and has the curtain board which separates the ink pressure room and driving means of the above-mentioned plurality, and the center position of each ink pressure room in ******** is shifted and arranged in the direction of a train to the center position of each ink pressure room within one train of a pressure room plate.

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OPERATION

[Function]
By arranging efficiently the array of two or more ink pressure plates which influence the magnitude of the whole equipment, the ink jet print head of this invention is small, and has realized equipment with comparatively easy manufacture.

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EXAMPLE

[Example]
First, the technique which will be the requisite is explained before explanation of the example of this invention. The opportunity of this invention is a request to the small drop on-demand ink jet print head which constituted two or more ink jet nozzles which each drives with the drive like a piezoelectric transducer in the shape of an array. I will consider the ink jet print head used for the printing equipment of a typewriter mold with which a print head prints on both directions by carrying out repetitive migration, and a print medium is perpendicularly sent out in a curved-surface top after that. In this case, a print head to which the die length of the perpendicular direction of a nozzle array is formed as small as possible, and dispersion in the distance from various nozzles to a print medium makes it as small as possible is desirable. This min vertical distance is equal to the inverse number of print linear density, and a number of a jet nozzle of products which print a specific color. For example, when printing by the consistency of 300 lines per inch by 48 nozzles which print black, the minimum vertical distance of the nozzle train becomes 47/300 inch.
Furthermore, it is desirable to also make the horizontal die length of a print head into min. Theoretically, as for the train of the perpendicular direction of 48 nozzles, in the case of black, level, and the head part printed perpendicularly, the die length to the core of the last nozzle becomes 47/300 inch from the core of the first nozzle about 300 lines per inch using 48 nozzles. It can print from the right end of paper (print medium) to a left end, without each nozzle carrying out excessive scan actuation in this configuration. If a nozzle is shifted horizontally and constituted, in order to print on all the fields on a print medium, only the shifted die length needs to take the margin of scan actuation, and it is necessary to scan it too much horizontally at least. By such excessive scan actuation, print time amount also turns long up and the width of face of the whole printer equipment will also become large. Therefore, in order to make width of face of equipment small, it is desirable to make horizontal spacing of a nozzle into min. Since the dimension of the longitudinal direction of a pressure transducer (a piezoelectric transducer and the septum at which it turns to the ink pressure interior of a room should put together) must be time [what] larger than the value of the inverse number of print linear density, it is necessary to shift a nozzle group somewhat horizontally, and it needs to arrange it. This die length to shift is decided by the dimension of a converter, and arrangement of a nozzle. Therefore, it is good to make this die length to shift into min.
The one approach of making horizontal spacing of a nozzle min is putting in no components in an ink pressure room or the boundary of the array of a pressure transducer. When it is in these pressure room or the same field as a converter, all other components are arranged on the outside of the array, or are arranged on the array (it is the upper location more nearly further than a nozzle group), or to the bottom (location near a nozzle group). For example, all the electrical installation to a converter can be prepared in the field of a pressure-transducer top, and all of another side, an inlet-port path, offset, a channel path, an output path, and a nozzle group can be prepared in an ink pressure room or the field of the pressure-transducer bottom. If two kinds of elements in these are prepared in the same field, since it will become obstructive mutually, it arranges in a mutually different field. Consequently, a horizontal gap of a nozzle

group is decided only by saying whether which makes two or more pressure transducers or ink pressure rooms approach, and they can be arranged. For example, an inlet-port path can be arranged in the field different from an offset channel path, and an offset channel path can be arranged in a different field from an outlet path. Therefore, what is necessary is to increase the thickness of a print head and just to make it multilayer structure, in order to make the perpendicular and horizontal dimension of a nozzle array into min.

The electronic drive circuit of IC configuration is cheaper than the case where a circuit is generally constructed from each components. It will become cheaper if the trigger of all the drive circuits in this IC can be carried out to the same moment. Therefore, when the nozzle group of a print head cannot be arranged perpendicularly at a single tier, the horizontal gap with one nozzle and the next nozzle will serve as an integral multiple of the inverse number of horizontal print linear density, if a cheap drive circuit is used. Although this requirement is eased when two or more drive circuits are used, horizontal spacing of all the nozzle groups driven by one IC becomes the integral multiple of the inverse number of horizontal print linear density.

Moreover, the actuation which makes driver voltage a low battery and injects an ink droplet at a high speed is possible, assembly is comparatively easy, and it is desirable to realize the small print head which can print multicolor ink. Generally, the print head having all of these descriptions is the most desirable. But each of each of these descriptions is desirable, and has contributed separately as a description of the ink jet print head of this invention.

Fig. 2 is one example of the ink jet print head of this invention, and the ink inlet port 12 to which ink is supplied is formed in the head body 10. The ink style path from the output 14 which forms an ink droplet further, i.e., a nozzle, and the ink inlet port 12 to a nozzle 14 is formed in the head body 10. Generally, including the nozzle array 14 by which the print head of this invention was constituted from many nozzles, these nozzles approach mutually, are arranged and are printed on a print medium (not shown) by the ink droplet injected from each nozzle.

The ink included in the ink inlet port 12 flows into the ink supply manifold 16. A typical ink jet print head has at least four manifolds which receive black, cyanogen, a Magenta, and yellow, respectively, and these are used for the print of black and subtractive primaries. However, the number of manifolds is printed by the design of a printer, for example, a black chisel, is printed in full color fewer colors, or can be changed according to a thing case. Ink passes through the ink supply channel 18 and the ink inlet port 20 from the ink supply manifold 16, and it flows into the ink pressure room 22. Ink flows out of the ink pressure room 22 through an outlet 24, and is supplied to the nozzle 14 which an ink droplet injects through the ink path 26. The arrow 28 shows the flow of ink.

As for the ink pressure room 22, one side face is formed by the flexible septum 34. The pressure transducer of this example is the piezo-electric ceramic disk 36 which fixed with the epoxy resin to the septum 34, and is stuck on the ink pressure room 22. As usual, although the piezo-electric ceramic disk 36 is not illustrated, it has the metal membrane layer 38 electrically connected to the electronic drive circuit. Although the pressure transducer of other configurations may be used, the pressure transducer of Fig. 2 operates in bending mode. That is, if an electrical potential difference is impressed to a piezo-electric ceramic disk, a disk tends to change magnitude. However, since the disk has fixed firmly to the septum, it brings a straight result. A variation rate arises in the ink in the ink pressure room 22 by this bending, ink flows outward through a path 26, and a nozzle 14 is supplied. After injection of an ink droplet, regrouting of the ink to the ink pressure room 22 is performed, when a pressure transducer 36 bends to the opposite side.

In addition to the output-flow path of above-mentioned ink, the alternative ink outlet 42, i.e., a purge channel, is formed in the head body 10. This purge channel 42 is connected to the inside part of the head which adjoins a nozzle 14 with the ink path 26. The purge manifold 44 is connected by this purge channel 42 from the ink path 25, and it has connected with the purge output port 48 through the output path 46 from this purge manifold 44. This purge manifold 44 is usually connected to the ink path corresponding to many nozzles by the purge channel 42 and the same channel. Although ink flows from the purge channel 42 to a manifold 44 and the purge path 46 as an arrow 50 shows during purge

actuation (removal actuation of air bubbles etc.), for details, it mentions later.
In order to make easy manufacture of the ink jet head of this invention, it is suitable to form the head body 10 with a multilayer board or multilayer sheets, such as stainless steel material. These multilayer sheets or multilayer boards are constituted from the example of Fig. 2 by the following various plates. The curtain board 60 forms the septum 34, the ink inlet port 12, and the purge outlet 48. The ink pressure plate 62 forms a part of ink pressure room 22, ink supply manifold, and a part of purge path 48. The division plate 64 forms a part of purge path 46 in a part of inlet port 20 of a part of ink path 26, one interface of the ink pressure room 22, and an ink pressure room and outlet 24, ink supply manifold 16, and a list. The ink inlet-port plate 66 forms a part of a part of ink path 26, inlet-port channel 18, and purge path 46. Moreover, another division plate 68 forms a part of ink paths 26 and 46. The offset channel plate 70 forms the principal part (offset channel part) 71 of a path 26, and a part of purge manifold 44. The division plate 72 forms a part of path 26 and purge manifold 44. The outlet plate 74 forms a part of purge channel 42 and purge manifold 44. The nozzle plate 76 forms the array-like nozzle 14. The alternative guard plate 78 protects a nozzle plate 76, and prevents possibility that a nozzle plate will receive a scratch and the damages on other.
Rather than the illustrated example, various ink paths, manifolds, and ink pressure rooms may be formed using many or a small number of metal plates, and the ink jet print head of this invention may be realized. For example, many plates may be used instead of forming the ink pressure room 22 with one plate, as shown in Fig. 2 . Moreover, it is not necessary to form all the various devices in a composite plate. For example, when manufacturing by chemical etching processing, the photoresist patterns used as a template for metaled chemical etching may differ for every field of a metal plate. Therefore, as long as it gives a more concrete example, the pattern of an ink inlet-port path is given on one field of a metal sheet, and it may be made to give the pattern of a pressure room on the field of the another side. Therefore, it is possible by controlling etching carefully to include a separate ink inlet-port path and an ink pressure room in a common metal layer.
In order to make assembly cost into the minimum, it designs so that all the metal layers of the ink jet print head except a nozzle plate 76 can be manufactured using comparatively cheap phot conventional pattern processes and conventional etching process. A machining process or other metalworking processes are not required. A nozzle plate 76 is completed through the following various processes. That is, they are the minute electron discharge method of electroforming from sulfur-containing nickel **, and 300 series stainless steel material, perforation of 300 series stainless steel material, etc. The last two processings are used in relation to the phot pattern processing and etching processing of all devices except the nozzle of a nozzle plate. Another, suitable processing is forming the remaining device of this plate by opening the hole of a nozzle, and standard **** processing. The print head of this invention is designed so that the conditions of the alignment between metal layers may not become severe. That is, the usual tolerance maintainable by chemical etching processing is suitable.
a certain suitable approach that a mechanical bolting machine with the suitable various multilevel-metal layers which form the ink jet print head of this invention is used -- alignment -- and it is combined. The suitable approach for association between metal layers is indicated by U.S. Pat. No. 4883219 (it corresponds to Japanese Patent Application No. No. 226369 [one to]), such as Anderson. According to the approach indicated by this specification, various metal layers are plated with a metal in 1/thickness of 8 - 1/4 micrometer. This metal to plate carries out diffusion association at a metal layer and fitness, and fits soldering, and even when reliable plating is possible for it and it does not use stainless steel material on the stainless steel material of a head, it can be plated good to the metal which forms that head. For example, gold can be joined together and soldered can plate upwards easily on stainless steel and very good. Various metal layers are accumulated in order on the alignment equipment of easy 2 pins after plating processing. This alignment equipment functions also as a diffusion coupler. the following processings are performed on these **** top wooden-clogs components.
(a) Carry out diffusion association of the thermal strain of various metal layers in the temperature requirement made into min, i.e., 400-500 degrees C.
(b) Remove a metal layer article from a diffusion coupler.

(c) Insert without cursing among a hydrogen ambient atmosphere and fixing in a furnace.
(d) Solder.
This joint process is performed in the state of sealing, and the bonding strength between components is strong, does not leave a height which plugs up a channel with a minute print head, does not make the device of each part of a print head distorted, and can realize a very high satisfaction level and the outstanding print head near 100% of abbreviation. It can be completed within [in 3 hours] from the beginning of a joint process to the last, being able to perform this production process using a standard gilding machine, a standard soldering furnace, and an easy diffusion coupler, and manufacturing many ink jet print heads. Furthermore, since the plated metal is very thin, and all diffuse almost in stainless steel, there is nothing of the metal layer plated on the occasion of a soldering process for which this metal gives an operation of chemical change, electrolysis, etc. to ink. Therefore, it is satisfactory even if it uses ink and the metal like copper which reacts easily at a joint process as a plated metal.
Including two or more piezo-electric ceramic disks made to metalize, the these piezo-electricity ceramic disk doubled the core on the corresponding ink pressure room 22 in Fig. 1, respectively so that it might be shown, and the electromechanical pressure translators 34 and 36 chosen as the ink jet print heads of this invention have fixed to the metal curtain board 60 with the epoxy resin. Fig. 1 is a decomposition perspective view of the various metal layers 60-78 used for the assembly of the nozzle array mold print head which has 16 jet nozzles. If this type-conversion machine is made into an approximate circle form, electromechanical effectiveness will become high most. the volume of the field of a piezo-electric ceramic component predetermined in this electromechanical effectiveness -- it relates to the variation rate. Therefore, effectiveness is higher than the thing of the rectangle mold in which the direction of this type-conversion machine operates in bending mode.
In order to manufacture a very small ink jet print head easily, as shown in Fig. 1, the various ink pressure rooms 22 are abbreviation flatness. That is, since the cross section is far larger compared with the depth, high pressure generates the pressure room 22 with the variation rate of the volume of a pressure room. Furthermore, all the ink pressure rooms of the print head of this invention are arranged suitable for the location of the same flat surface in an ink jet print head, or the same depth. However, this is not indispensable requirements. The location of this pressure room is decided in the field of the metal plate 62 of one or more sheets, as shown in Figs. 2 and 1.
In order to form a head in high density, the ink pressure room 22 arranges in parallel the field of at least 2 trains which shifted the geometrical hit alignment of each other. Moreover, these pressure room is mutually separated by very few sheet-like ingredients. Generally, although this sheet-like ingredient remains between pressure rooms, this is for raising the dependability of association between metal layers so that the leakage of ink may not take place between metal layers. As shown in Figs. 1 - 7 (Fig. 3 shows the configuration covering the various layers of Fig. 1 superficially, Fig. 4th [the] and 5 shows the 2nd example of this invention, Fig. 6 shows the 3rd example of this invention, and Fig. 7 is drawing having shown each part repeatedly) The suitable example includes the train of at least four parallel ink pressure rooms 22, and the core of these trains is located in the location [core / of the next train] shifted. Especially, at the circular pressure room of Fig. 1, the location of the train of four parallel pressure rooms is shifted, and if the core of each pressure room is connected in a straight line, the array of a hexagon will be formed. What is necessary is just to arrange it in the shape of a forward hexagon to make it the smallest structure, although the core of a pressure room is located in the shape of [of an inequality side hexagon] an array. This array may increase the number of the pressure room which extends to which direction at arbitration and is established in an ink jet print head, and nozzles. In order to make it operate efficiently generally, it is desirable to have direction-magnitude, such as abbreviation, in the direction of the cross section of a pressure room. Therefore, it is thought that the pressure room of an approximate circle form is very efficient. However, the pressure room of other structures which the cross section made the hexagon, for example is also substantially isotropic about the cross section, and it is thought that it is efficient. Although the pressure room of other structures can also be adopted, direction-things, such as abbreviation, are desirable about the cross section.
Although the typical thickness of the piezo-electric ceramic disk 36 is 0.010 inches, it may be thinner

than it or may be thick. Although it is the ideal which is made an approximate circle form according to a circular ink pressure room, if these disks form these disks in a hexagon, although it is small, required driver voltage will go up. Therefore, these disks can be cut off and made from a circular saw etc. from a big base material. Only 1/1000 inch only of numbers of the diameter of the inscribed circle of the piezo-electric ceramic disk 36 of these hexagons is usually smaller than the diameter of the corresponding pressure room 22, and the 1/thousands of inches diameter of the circumscribed circle of these disks is large. The typical thickness of the septum layer 60 is 0.004 inches.

As Fig. 2 was explained, it connects with the nozzle to which each pressure room corresponds by the ink path 26. Generally, each of these paths 26 consist of the 1st section 100 where only the 1st distance was perpendicularly prolonged in the corresponding pressure room 22, the 2nd (offset channel) section 71 where only the 2nd distance was prolonged in the 2nd direction parallel to the field of the pressure room 22, and the 3rd section 104 which extended in the direction of the nozzle which is perpendicular to the 2nd direction and corresponds. The location of the nozzle 14 of two or more trains is decided to make main spacing between nozzles narrower than main spacing between corresponding ink pressure rooms by the offset channel section 71 of a path 26.

The offset channel section 71 is the principal part of a path 26. Furthermore, it is arranged between the path 26 and the nozzle corresponding to the ink pressure room 22 and them in especially an offset channel section. As for a pressure room and the path 26 corresponding to a nozzle, it is desirable for die length and the magnitude of a cross section to be equal. therefore, the thing which each jet devices of all will have the same resonance characteristic, and it will drive by the same wave if the inlet-port channel of a pressure room assumes that die length and the magnitude of a cross section are the same -- the abbreviation from various nozzles -- it becomes possible to print in the same ink droplet injection property. Furthermore, since the offset channel section 71 is usually formed in the single common metal plate, if it pulls in the thickness of an ink jet print head, it can make weight and cost the minimum. In Figs. 1 - 8, and 15 (Fig. 8 shows the 4th example of this invention, and Fig. 15 shows a part of this example), the offset channel section 71 has connected between circulation spaces 100 and 104. If 0.135 inches of spacing of the center to center of the pressure room arranged to the hexagon become, the distance from the core of the end of an offset channel section to the core of the other end will be 0.116 inches. That is, the die length of the geometric property of an equilateral triangle to an offset channel section is the pitch of an ink pressure room. $\sqrt{3} / 2$

It is equal to what carried out multiplication. Furthermore, although the width of face of the end which the offset channel 71 has next to a nozzle is 0.015 inches, the width of face of the other end is 0.024 inches. Of course, these values can be changed. For example, the width of face of the other end of this channel was examined in 0.020-0.036 inches, and the good result was obtained. Although the typical thickness of an offset channel is 0.20 inches, this thickness may form the same layer of two sheets in piles.

Again, Figs. 1 - 3 are referred to. a nozzle 14 -- the field of the metal watch 62, and the corresponding field of the ink pressure room 22 -- abbreviation -- it has a perpendicular medial axis. Furthermore, if the medial axis of these nozzles is extended until it intersects the metal watch 62, it has crossed and shifted to the corresponding ink pressure room. With the ink jet print head of Figs. 1 and 3 , the nozzle 14 is arranged at one train. Arranging linearly does not need to arrange this not necessarily linearly [********]. On the other hand, the ink pressure room 22 connected to these nozzles is arranged at four trains. Furthermore, the dimension beside a pressure room is arranged by 0.110 inches, and the hexagon array of these pressure room 22 is arranged at intervals of 0.135 inches. Therefore, these ink pressure room approaches only at intervals of a critical mass required for association of a metal layer, and is prepared. Although the diameter of a nozzle had the good range of 35-85 microns, it is not necessarily restricted to this range. Since diffusion of the ink droplet of a print medium is restricted in order to print 300 dots per unit inch by water color ink, as for the diameter of a nozzle, it is desirable to make it about 75 microns. In these examples, the suitable thickness of a nozzle plate is about 63-75 microns, i.e., 0.0025-0.0030 inches.

Furthermore, in the configuration top of Figs. 1 and 4, especially an offset channel, main spacing between the nozzles which can be set working is about 0.0335 inches. If the line of a nozzle is in the location which rotated only the include angle of arc tangents 1/10 from the horizontal position in the case of this spacing (refer to the 8th Fig.), the vertical distance between ****** nozzles will become 1/300 inch exactly, and corresponding level spacing will become 10/300 inch. In the case of spacing of the level and the perpendicular direction of these, the print head is set up so that it may print on horizontal and vertical both directions by the consistency of 300 dots per unit inch.
I will consider the ink jet print head which has the configuration of an above-mentioned ink pressure room and a nozzle. Moreover, the number of the level dots between h and a nozzle is assumed [the inverse number of a perpendicular print consistency] to be n for the inverse number of v and a level print consistency. In this case, if Fig. 7 is referred to and spacing of the train of C and a pressure room will be set [spacing between nozzles] to L for s and main spacing between pressure rooms, the following relational expression will be materialized.

$$s = \sqrt{v^2 + (nh)^2}$$

$$C = 4s = 4\sqrt{v^2 + (nh)^2}$$

$$s = (\sqrt{3}/2)\,C = 2\sqrt{3}\sqrt{v^2 + (nh)^2}$$

Furthermore, as a concrete example, if it is v=h=1 / 300 inches, as shown in the following tables, the value of s, C, and L will be chosen to the value of various n.

[表]

n	s(インチ)	C(インチ)	L(インチ)
10	.0335	.1340	.1160
9	.0302	.1207	.1046
8	.0269	.1075	.0931
7	.0236	.0943	.0816
6	.0203	.0811	.0702

Values other than this are calculable similarly. Moreover, the integral multiple of the inverse number of the level print consistency of level spacing between nozzles can apply the same count without limit.
In Fig. 7 , the ink inlet port 20 and the ink outlet 24 of the pressure room 22 are completely established [the pressure room] for 4 ****** in the opposite side. Only one train of a nozzle 14 is arranged along the center of an ink jet print head, and an ink supply manifold (refer to Fig. 1 and the 8th Fig.) is in the outside of the boundary of an ink pressure room array. Since the flow of the ink of a pressure room is good in the case of restoration of ink, and purge actuation, a bubble and an impurity are easily removed from the inside of ink by the inlet port and outlet which were established in these antipodes. Since the configuration of the inlet port of this ink and an outlet makes both distance max, acoustical degree of separation's improves certainly. Furthermore, an ink outlet becomes near by the nozzle rather than an ink inlet port, and ink becomes easy to flow.
Therefore, with the illustrated structure, the nozzle which corresponds at spacing made to approach further rather than spacing approached between pressure rooms may be arranged. For example, if main spacing of a pressure room is set to X, it is suitable for main spacing of the nozzle corresponding to this to make it the die length of the quadrant of X so that an above-mentioned example may show. As for spacing of the nozzle within the train same in order to make it a symmetrical configuration, it is desirable to consider as the inverse number of the number of the trains of the ink pressure room corresponding to the nozzle train. It follows, for example, when the number of the trains of the ink pressure room corresponding to the nozzle of one train is 6, it is good to set main spacing of the nozzle

of the train to 1/6 of main spacing of the train of an ink pressure room corresponding. Consequently, the very small ink jet print head which spacing of a nozzle was made to approach is realizable. When a more concrete example shows the point that the ink jet print head of this invention is small, the nozzle array containing 96 nozzles of Fig. 7 is about 0.07 inches in die length of about 3.8 inches, 1.3 inch of ****, and thickness.

Figs. 1 and 3 show the ink outlet channel 42 which connects the ink outlet manifold 44 of Fig. 2 to a nozzle 14, i.e., the channel for a purge. Usually, these channels and manifolds that were added further are only used only during the purge actuation period for the first Jet ink restoration actuation and cellular removal. Since a bulb (not shown) is used for closing the purge outlet 48, when not used, it does not flow for the purge style path 50. U.S. Pat. No. 4727378 by Li etc. is indicating the detailed structure of such a purge outlet. Generally, the path of ink is prepared out of the minute nozzle group 14 by the channel and manifold for a purge at each ink jet. Consequently, air bubbles and other impurities can be removed from an ink jet head, without passing a nozzle. These ink outlet channels and manifolds that were added did not produce at all effect which degrades the engine performance of the ink jet print head of this invention. Although the die length of a channel 42 is adjustable, for die length, 0.300 inches and width of face are [0.010 inches and the thickness of a suitable dimension] 0.004 inches. If the channel for a purge and an outlet are lost, since the metal plate of the print head for constituting these is removable, the thickness of the print head of this invention can be reduced.

The ink supply channel 18 is formed in the plate 66 between the ink pressure room 22 and an ink nozzle 14 in Figs. 1 thru/or 3 . It is assumed that an ink jet print head is the structure of having the ink pressure room of four trains. In this case, in order to make it the ink feed hopper of two trains inside a pressure room not let between the pressure rooms of two trains of the outside of an ink jet pass, it will be necessary to increase spacing between pressure rooms, and an ink feed hopper will be connected with the pressure room of the plate located in the ink pressure room bottom. That is, the ink feed hopper is prolonged into the plate between a pressure room and a nozzle from the outside of an ink jet head. These ink feed hopper is prepared so that a location may be in agreement with a pressure room, respectively, and it is connected to the pressure room from the pressure room bottom.

In order to make fluid impedance of the inlet-port channel of the pressure room of an inside train equal to the fluid impedance of the inlet-port channel of the pressure room of an outside train, these channels can be made from two different structures which has the same cross section and the same die length. That is, please care about the structure of 102a and 102b of Fig. 1 and Figs. 3 , 8, and 13. The characteristic impedance to a fluid is decided by the die length and those cross-sectional area of an inlet-port channel, and this is chosen so that the engine performance of a request of an ink jet head may be attained, and the need of making the inlet port 20 of a pressure room into the shape of a small hole or a nozzle is avoided. Die length of 0.275 inches, width of face of 0.010 inches, and the thickness of the dimension of a typical inlet-port channel are about 0.001-0.016 inches according to the viscosity of ink. In the case of water color ink, in the case of hot melt ink [about one to 15 centipoise, and], the viscosity of ink is about ten to 15 centipoise extent. An important thing is deciding the magnitude of an ink inlet port to be able to supply sufficient ink for making it operate with the full speed of a request of an ink jet print head, and to maintain the acoustical separation condition of an ink pressure room good here.

As for the manifold for inlet ports, and the manifold for outlets, it is desirable to arrange on the outside of the boundary of the pressure room of four trains. Furthermore, making the volume of ink into the minimum, the dimension of the cross section of these manifolds is optimized so that compliance to the extent that sufficient ink for a nozzle can be supplied when all the ink jet nozzles are driven to coincidence, and the interaction between jet nozzles is made to the minimum may be maintained. The dimension of the typical cross section of this manifold is 0.12x0.02 inches. If an outlet channel and an outlet manifold are lost, the ink jet print head of this invention can be further miniaturized by arranging the manifold for inlet ports between a pressure room and a nozzle in the same layer as the offset channel 71. This example is shown in Figs. 4 and 5 . the advantage of the structure of this latter -- the inlet-port channel 18 of both the train inside a pressure room, and an outside train -- it is good by the same structure, i.e., the same cross section, and the same die length. If an outlet channel is lost, it will enable a

layer 72 to support a thin nozzle layer further firmly. In the bottom of the train of the outside of a pressure room, if an inlet-port manifold is arranged completely, the array of the same hexagon as the pressure room of the first four trains can be extended, and the train of further many pressure rooms can be prepared. That is, it becomes possible to form the pressure room of further many numbers into a layer 62. This example is shown in Fig. 6 at the detail. Furthermore, Figs. 9 - 18 are drawings showing the structure of the suitable various layers for the ink jet print head shown in Fig. 8.

Although ink is supplied to two or more ink supply channels from each manifold, according to the design of this invention, between the ink pressure room connected to the common manifold is separated acoustically. That is, in above-mentioned structure, an ink supply manifold and an ink supply channel function as an acoustical RC circuit substantially, and attenuate a pressure pulse. It generates at an ink pressure room, and such a pressure pulse goes back from the pressure room to a common manifold through an inlet-port channel, can go into the inlet-port channel of the next door of a manifold, and has a possibility of having a bad influence to the next jet nozzle. In this invention, since the effectiveness of compliance is acquired by these manifolds and the acoustical separation effectiveness is further acquired by the inlet-port channel, these pressure rooms are separated acoustically mutually. Dissociating acoustically means not being influenced by actuation of other jet nozzles by which the ink injection property of one jet nozzle was connected to the same manifold at all. It was observed that the injection period of an ink droplet is attained in 10 or less microseconds, and this acoustical separation was usually attained with the period of less than 3 microseconds. In a cross talk of this level, a print result is not affected at all.

In order to follow more the path of the ink style of the ink jet print head of this invention to accuracy, it explains with reference to Figs. 1 and 3 .

Ink is supplied to the ink manifold 130 (layers 62 and 64) through the ink inlet port 12 (layer 60). The ink from a manifold 130 is supplied to one inlet-port 132a of inlet-port channel 102a (layer 66). The ink from inlet-port channel 102a is sent to pressure room 22a (layer 62) through inlet-port 20a (layers 66 and 64) of a pressure room. According to an ink droplet injection pulse or purge actuation, ink flows to nozzle 14a (layer 76) through connecting path 100a (layers 64, 66, and 68) from pressure room 22a, offset channel 71a (layer 70), and path 104a (layers 72 and 74). Opening 136a of a guard plate 78 is prepared according to the location of nozzle 14a, and is larger than nozzle 14a. During purge actuation, the great portion of ink which reached ink path 104a is sent from a nozzle through purge channel 42a to path 138a (layers 74 and 72). These paths are expanded as illustrated, and they are connected to the manifold 44 for a purge. Ink is outputted through the outlet 46 (layers 68-60) for a purge from the manifold 44 for a purge.

Similarly, ink flows from a manifold 130 to inlet-port 132b (layer 66) of one manifold of inlet-port channel 102b, and the ink from inlet-port channel 120b is supplied to pressure room 22b through pressure room entrance 20b (layers 66 and 64). The ink from pressure room 22b is sent to nozzle 14b (layer 76) through connecting path 100b (layers 64, 66, and 68), offset channel 71b (layer 70), and path 104b (layers 72 and 74). The ink droplet from nozzle 14b is injected through opening 136b prepared in the guard plate 78. The great portion of ink which reached during purge actuation at path 104b is sent to the manifold 44 for a purge from path 138b (layers 74 and 72) through purge channel 42b. The ink from this manifold 44 flows out of a print head through the purge outlet 46 as mentioned above.

In the ink jet print head of Fig. 1, the manifold 44 for an ink purge of a top and the bottom and 44' are in the ink supply manifold 130 and 130' list of the bottom and the bottom. He can understand the ink style path to the remaining nozzles easily from above-mentioned explanation. Although used for usually printing black ink, the ink jet print head of Fig. 1 is usable although the ink of two colors is printed, in that case, supplies one color ink to manifold 130' of Fig. 1 top, and should just supply the color ink of another side to the lower manifold 130.

Similarly, I will follow the ink style path of Figs. 4 and 5 . The same reference mark is given to the element of these drawings corresponding to each element of Fig. 1 for convenience of explanation. In Figs. 4 and 5 , ink flows to the manifold 130 of a layer 70 from the ink inlet port 12 (layers 60, 62, 64, 66, and 68). Same inlet-port 12' is prolonged in upper ink manifold 130' from these layers. The ink from

a manifold 130 is supplied to the end of ink inlet-port channel 102a through path 132a (layers 66 and 68). The ink from channel 102a is supplied to the ink inlet port of the lower limit of pressure room 22a through path 20a (layers 66 and 64). The ink from the upper limit of pressure room 22a is supplied to the lower limit of a offset 71a of a layer 70 through path 100a (layers 64, 66, and 68). The ink from the upper limit of this offset channel is sent to nozzle 14a (layer 76) through path 104a (layer 72). Opening 136a of a guard plate 78 is prepared according to the location so that output, i.e., nozzle, 14a may be surrounded.

The ink style path to nozzle 14b which corresponds from the ink style path of going to ink pressure room 22b, and this ink pressure room 22b is the same as an above-mentioned ink style path. Therefore, the element of this ink style path gives suffix b to the same reference number as the element with which a **** corresponds, and the explanation beyond this is omitted. The print head of Fig. 4 is used for the print of the ink of a single color (for example, black) or two colors like 1st [**] Fig. ink jet print head. Furthermore, in the example of Fig. 4, the manifold for a purge and the purge channel are removed as mentioned above.

Fig. 6 is a decomposition perspective view of the ink jet print head which extends this invention and is obtained easily. Although this print head has further many manifolds for more color ink, contiguity spacing of the pressure room 22 and an ink jet nozzle is held.

Ink is supplied to each of the manifold 130 prepared in the layer 70, 130', 130", and 130** through an inlet port 12, 12'12", and 12**, respectively. Although these four manifolds support black, cyanogen, a Magenta, and yellow, respectively, such sequence is good anyhow. It will not be necessary to explain further, since the detail of the ink style path about these various ink pressure rooms is the same with having explained Fig. 4. However, the ink style path of the element relevant to the pressure rooms 22a and 22b which attached the reference mark corresponding to the reference mark of Fig. 4 is illustrated for convenience.

The ink jet print head of Fig. 8 is used for the both-way printing device similar to a typewriter. This device can carry out a full color print to horizontal and vertical both directions by the print consistency of 300 dots per inch. It was checked that the actuation which can trust this print head to the rate which prints about 11000 ink droplets in 1 second per nozzle is maintained. It has the train of 48 nozzles used for printing the ink jet print head black ink of Fig. 8. It also has the train of 48 nozzles used for this print head printing color ink further, and it separates into black ink with a train, and this train is prepared in the location horizontally shifted. 16 nozzles in 48 nozzles for these colors are the objects for cyanogen ink, and are other objects for 16 Magentas, and the 16 remaining pieces are the objects for yellow.

The layout of the print head of Fig. 8 can be easily changed into the nozzle configuration of one train instead of two trains. Even if the operating characteristic of this ink jet print head makes this change, it is not influenced at all.

Figs. 9 thru/or 18 are drawings of each part for the ink jet print head which has 96 nozzles of Fig. 8. The spacer plate 59 with which Fig. 9 equips with a converter, and Fig. 10 A curtain board 60 and Fig. 11 the ink pressure room plate 62 and Fig. 12 a division plate 64 and Fig. 13 -- a division plate 72 and Fig. 17 show a nozzle or the output dead plate 76, and, as for the division plate 68 and Fig. 15, Fig. 18 shows the guard plate 78 for the ink inlet-port plate 66 and Fig. 14, respectively, as for the offset channel plate 70 and Fig. 16. This print head of Fig. 8 is designed so that it may have the ink receptacle manifold of a large number which receive various color ink. In the illustrated example, it has a five-set manifold and two manifold sections are included for every set. Since these manifold sets are separated mutually, this ink jet print head can receive five kinds of color ink. It can follow, for example, this ink jet print head can receive the black ink for the ink of the cyanogen Magenta for a full color print, and the subtractive color mixture of yellow in three primary colors, and the print of a text. The 5th color which mixed and made cyanogen, a Magenta, and yellow on the print medium as 5th color ink may be used. Moreover, since black ink is usually used in case it prints a text and a graphic form, you may make it supply black ink to two or more manifold sets. [than color ink] [more] This concrete application is explained below. Furthermore, distance between the corresponding nozzles to which ink is supplied from each manifold section and manifold section can be made into min by establishing two or more manifold

sections in each color ink. In case this meets horizontally for example, during a print and an ink jet print head goes, dynamic change of the ink pressure generated by accelerating and slowing down an ink droplet can be controlled to min.
The various layers which constitute the example of Fig. 8 of this invention are explained with reference to Figs. 9 thru/or 18 about the path of the flowing ink.
Fig. 9 shows the spacer plate 59 which has the opening 140 equipped with the piezo-electric ceramic converter 36 of Fig. 8. This spacer plate 59 is arbitration components, serves as an outside front face of a piezo-electric ceramic crystal, and coplane relation, and makes the backside of an ink jet print head a plane. Two or more ink feed hoppers for supplying ink to a print head are prepared so that this layer 59 may be penetrated. These ink feed hoppers are shown by the reference mark of 12c (c shows the feed hopper of the color ink of cyanogen), 12y (y shows yellow), 12m (m shows a Magenta), 12b1 (b1 shows the 1st black ink), and 12b2 (b2 shows the 2nd black ink). For convenience, in the following explanation, c, y, m, b1, and b2 are used in order to show the components relevant to the path for which each ink of cyanogen, yellow, a Magenta, the 1st black, and the 2nd black flows, respectively. Please care about that there is no need of supplying the color ink of these versatility to an ink jet print head in the sequence indicated here. However, the ink jet PU head shown in Figs. 8 - 18 has 48 nozzle groups for the color print of the section on the left-hand side of a print head, and 48 nozzle groups for the black print of the right-hand side section of a print head so that it may mention later.
In the septum 60 of Fig. 10, ink feed hopper 12c-12b2 have penetrated this layer 60, respectively.
Feed hopper 12c of cyanogen is connected to the cyanogen ink supply channel 142 which leads to two cyanogen manifold section 130c and 130c' in Fig. 11. Manifold section 130c is prepared so that the central part of the outside bottom of the left-hand side array of the pressure room 22 may be adjoined. Manifold section 130c' adjoins the part at the upper left of the left-hand side array of a pressure room, and is arranged. Furthermore, the ink feed hopper 12b2 of this layer 62 leads to the channel 144 connected to the black ink manifold section 130b2 and 130b2'. The manifold section 130b2 adjoins the lower right part of the right-hand side array of the pressure room 22, and is prepared, and manifold section 130b2' adjoins the upper right part of the right-hand side array of the pressure room 22, and is prepared.
Yellow ink feed hopper 12y leads to the channel 146 of a layer 62. In addition, connection of the Yellow ink to Yellow ink manifold section 130y and 130y' of Fig. 11 is made in another layer. Moreover, 12m of Magenta ink feed hoppers and the 1st black ink feed hopper 12b1 have penetrated this layer 62. These ink feed hoppers are connected to the Magenta and the black ink manifold, i.e., the part shown in Fig. 11 by 130m, 130m', 130b1, and 130b1', in other layers of a print head, respectively. Not ten pieces but required ink supply number of connections requires [whether it is small and] only five pieces by preparing a communication channel as shown by the number of 142, 144, and 146 between the separated manifold sections. Furthermore, by preparing a manifold ranging over two or more layers, it can be made to be able to increase, the depth, i.e., the volume, of a manifold, and, thereby, acoustical compliance can be improved.
As shown in Fig. 12, according to the location of the manifold of the layer 62 of Fig. 11, and a communication channel, the same manifold and communication channel of a layer 64 are arranged. Similarly, in the layer 66 of Fig. 13, since the part of an ink supply manifold has attained to even the layer 66, the acoustical compliance of a manifold is increased further. Moreover, the layer 66 also contains path 12y and 12y'. These paths lead to the edge of the communication channel 146 of the layers 62 and 64 of Figs. 11 and 12. Moreover, the increment in the volume of these manifolds and the increment in acoustical compliance are restricted by this layer 66.
In Fig. 14 and 15 Fig., it connects with the communication channel 148 and 12m of Magenta ink feed hoppers is connected to Magenta manifold section 130m and 130m' through this channel. Furthermore, Yellow ink feed hopper 12y is connected to manifold section 130y (Fig. 14) through the channel 150. Moreover, ink feed hopper 12y' is connected to Yellow ink manifold section 130y' (Fig. 15) through the channel 154. Furthermore, it connects with layers 68 and 70 (14th [the] and 15 Figs.) through a path 156, and the black ink feed hopper 12b1 leads to the black ink manifold section 130b1 and 130b2

through this path further.
Therefore, ink is supplied to each ink manifold section by the above-mentioned approach. Moreover, the volume of each manifold section is increasing by preparing the part of a manifold section ranging over a multilayer field.
The path supplied to the black as which ink was chosen from these manifold sections, cyanogen, a Magenta and the ink pressure room 22b1 of yellow, 22b2, and 22c, 22m and 22y is explained further. Moreover, the path of the ink style from these ink pressure rooms to the nozzle corresponding to them is also explained. He can also understand easily the ink style path to other pressure rooms and nozzles.
[explanation / this]
In Figs. 13 and 14, the ink from cyanogen ink manifold section 130c' flows to ink feed hopper 132of ink supply channel 102c c. The ink from channel 102c is supplied to the upper part of ink pressure room 22c (layer 62 of Fig. 11) through feed hopper 20c (Fig. 12 and layers 64 and 66 of 13 Fig.) of an ink pressure room. Ink flows through pressure room 22c to path 100c (layers 64, 66, and 68 of 12th, 13, and 14 Fig.), and flows to offset channel 71c (layer 70 of Fig. 15) further. It flows to nozzle 14c (layer 76 of Fig. 17) to which ink corresponds through opening 104c (layer 72 of Fig. 16) from the lower limit section of offset channel 71c. This nozzle 14c is prepared in the covering protective layer 78 (Fig. 18) according to the location of opening 136c.
Similarly, the ink from Yellow ink manifold section 130y (Fig. 14) flows to inlet-port 132of ink supply channel 102y y (Fig. 13). The ink from ink supply channel 102y is supplied to the upper part of ink pressure room 22y through path 20y (layers 66 and 64 of the 13th and 12 Fig.). The ink from the lower part of this ink pressure room flows through path 100y (layers 64, 66, and 68 of 12th, 13, and 14 Fig.) in the lower limit section of the offset channel 71 (layer 70 of Fig. 15). The ink from the upper limit section of this offset channel flows to nozzle 14y (layer 76 of Fig. 17) through opening 104y (layer 72 of Fig. 16). Opening 136y of a protective layer 78 has lapped with nozzle opening 14y. Similarly, the suffixes m, b1, and b2 which correspond, respectively are given to the reference number of the element relevant to the path of ink of frequenting ink pressure room 22m, 22b1, and 22b2.
In Figs. 8, 15, and 17, black ink is supplied to 48 offset channels of the right-hand side array of Fig. 15 by arrangement of an above-mentioned manifold along with 48 nozzles contained in the right-hand side train of the nozzle of the plate 46 of Fig. 17. Furthermore, cyanogen ink is supplied to the first eight offset channels of the train of the offset channel array top on the left-hand side of Fig. 15, Magenta ink is supplied to the eight next offset channel, and Yellow ink is supplied to eight offset channels of the same train and also the 3rd group. Furthermore, Yellow ink is supplied to the first eight offset channels of the bottom train of a left-hand side offset channel array, cyanogen ink is supplied to the following eight offset channels, and Magenta ink is supplied to the following eight offset array. Thus, by constituting the train of the upper and lower sides of the offset channel of Fig. 15 from an interleave method, the color ink assigned to the nozzle of the print head of Fig. 17 which has this structure by the interleave method is supplied. That is, the ink of a different color is supplied to ****** each nozzle in the perpendicular direction of the nozzle group of the train on the left-hand side of Fig. 17. By this configuration, since the vertical separation of the nozzle of the ink of a certain color separates by at least 2 dots, color printing becomes easy. By adopting arrangement of such a manifold, and the ink supply approach, it is possible to change easily the array of the color supplied to a nozzle by the interleave method by request.
Thus, the example of this invention of Fig. 8 is small, manufacture is easy, and the ink jet print head which has the function which was excellent in versatility is realized.
Although the suitable example of this invention was explained above, it is clear to this contractor that various deformation and modification can be carried out if needed, without not limiting this invention only to the example explained here, and deviating from the summary of this invention.

[Translation done.]

* NOTICES *

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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
Fig. 1 the decomposition perspective view of the suitable example of the ink jet print head of this invention, and Fig. 2 Drawing of the ink jet print head of the single nozzle used as the base of this invention, and Fig. 3 The mimetic diagram showing superficially the configuration covering the various layers of the ink jet print head of Fig. 1, and Fig. 4 The decomposition perspective view showing other suitable examples of this invention, and Fig. 5 The configuration covering the various layers of the ink jet print head of Fig. 4 a superficial **** mimetic diagram and Fig. 6 The decomposition perspective view of still more nearly another example of this invention, and Fig. 7 The example decomposition perspective view of everything [Fig. / an ink pressure room, an ink feed hopper, an ink output path and the mimetic diagram showing an offset channel repeatedly, and / 8] but this invention and Figs. 9 or 18 are top views of each class which constitutes the ink jet print head of Fig. 8.
60: The 4th plate (septum layer)
62: The 2nd plate (ink pressure room layer)
64, 66, 68, 70, 72: The 3rd plate (ink path layer)
76: The 1st plate (nozzle layer)

[Translation done.]

* NOTICES *

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2.**** shows the word which can not be translated.
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DRAWINGS

[-- the -- 1A Fig.]

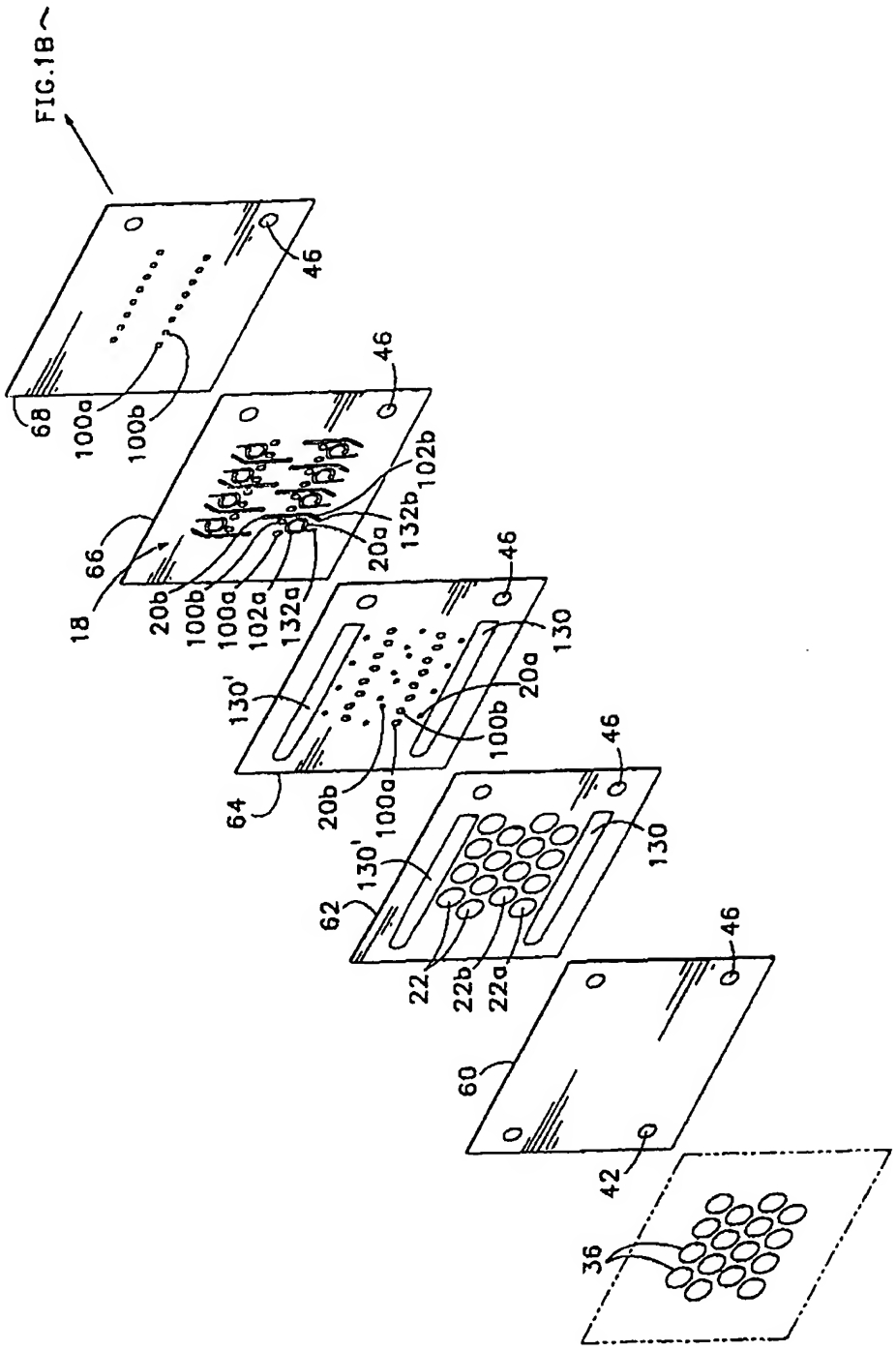


FIG.1B
46
68
100a
100b
102b
132b
20a
66
18
20b
100b
100a
102a
132a
130
130'
64
62
22
22b
22a
60
42
36

[-- the -- 1B Fig.]

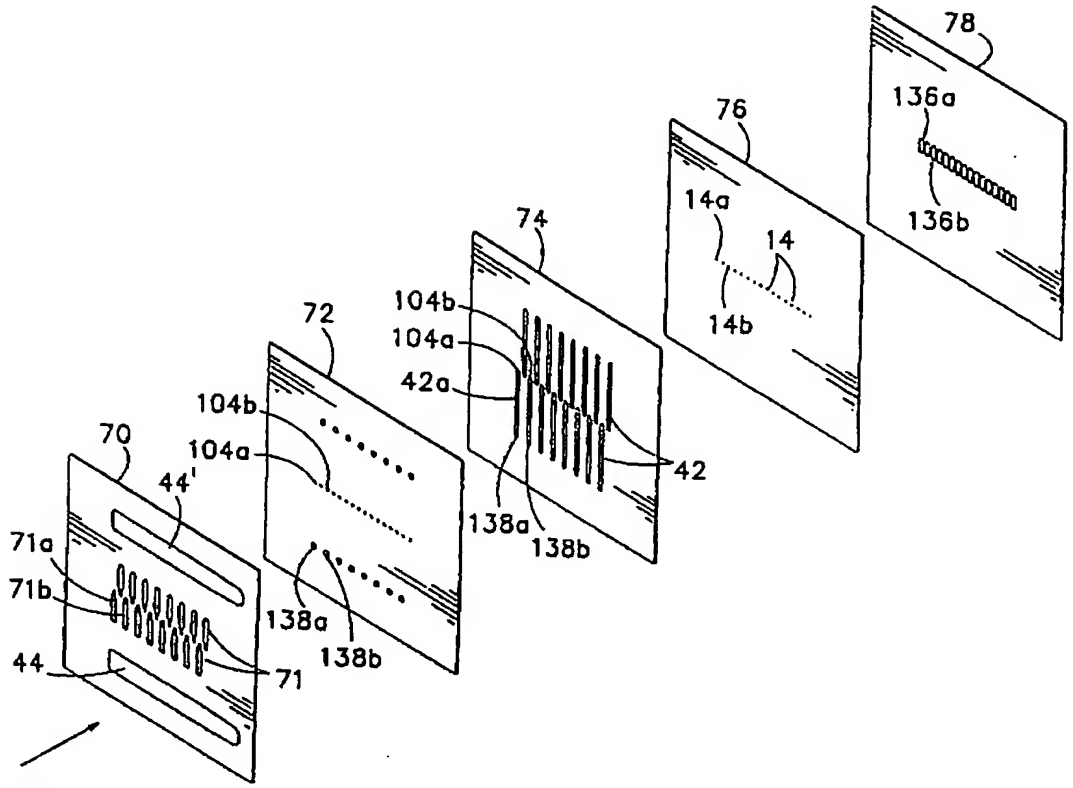
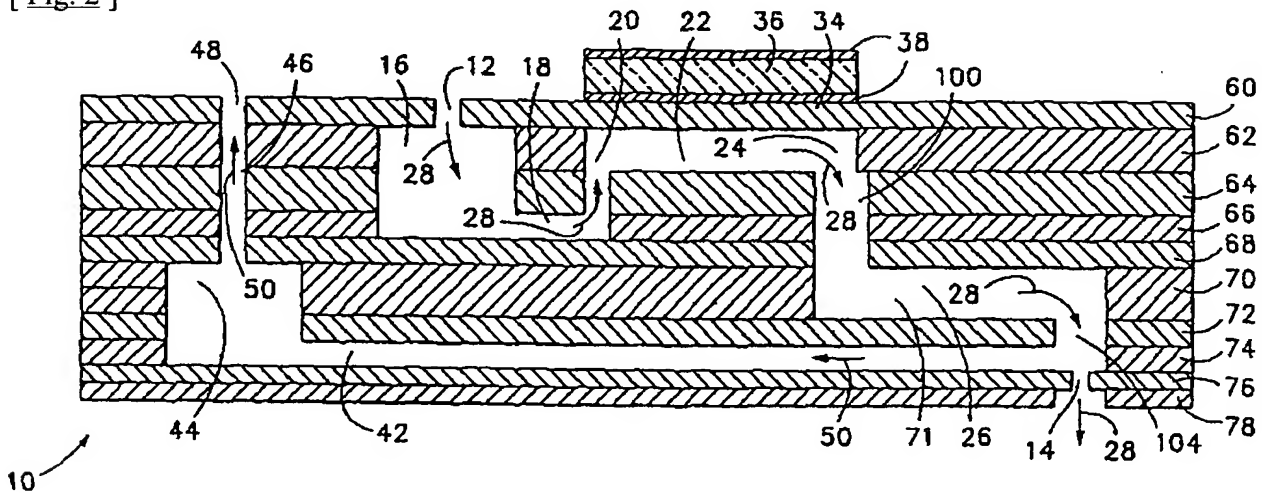
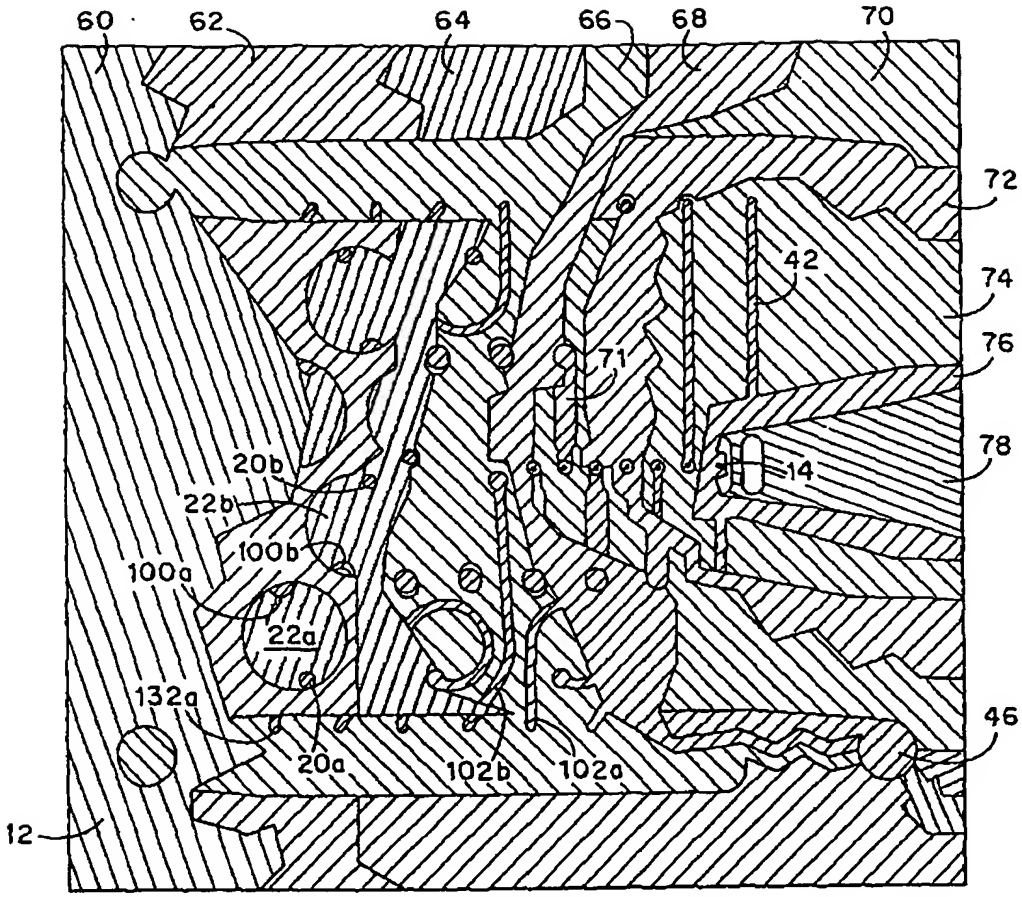


FIG.1A から

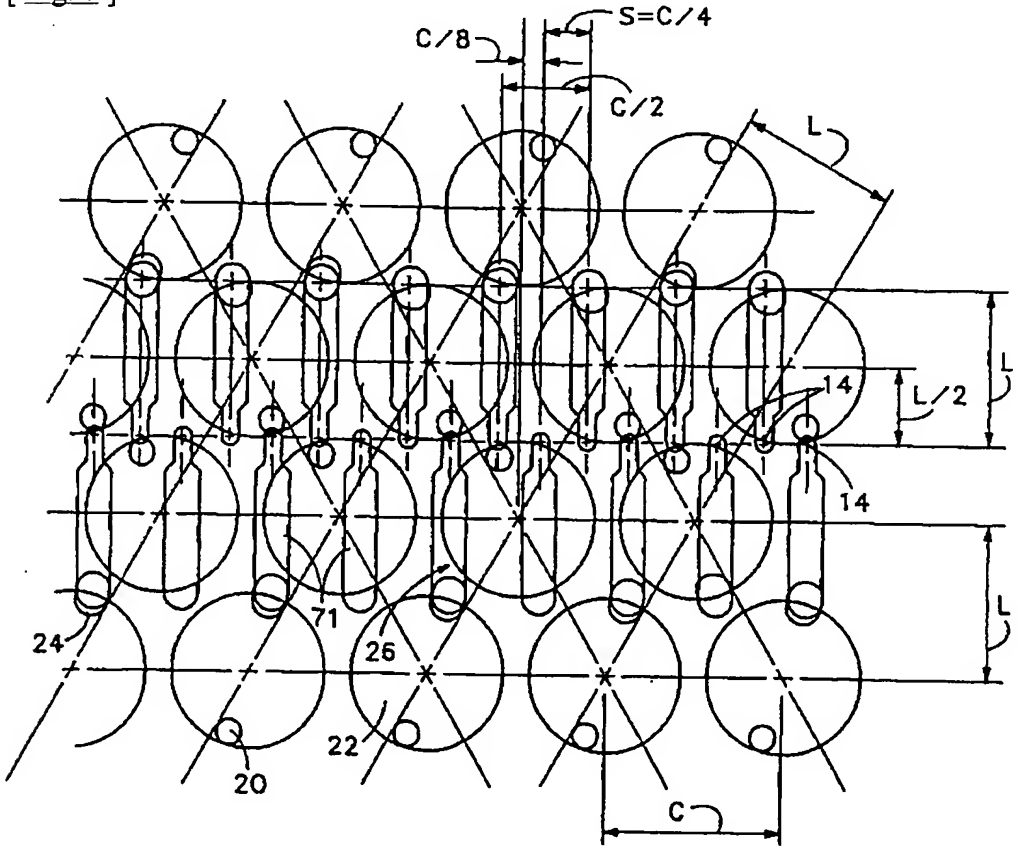
[Fig. 2]



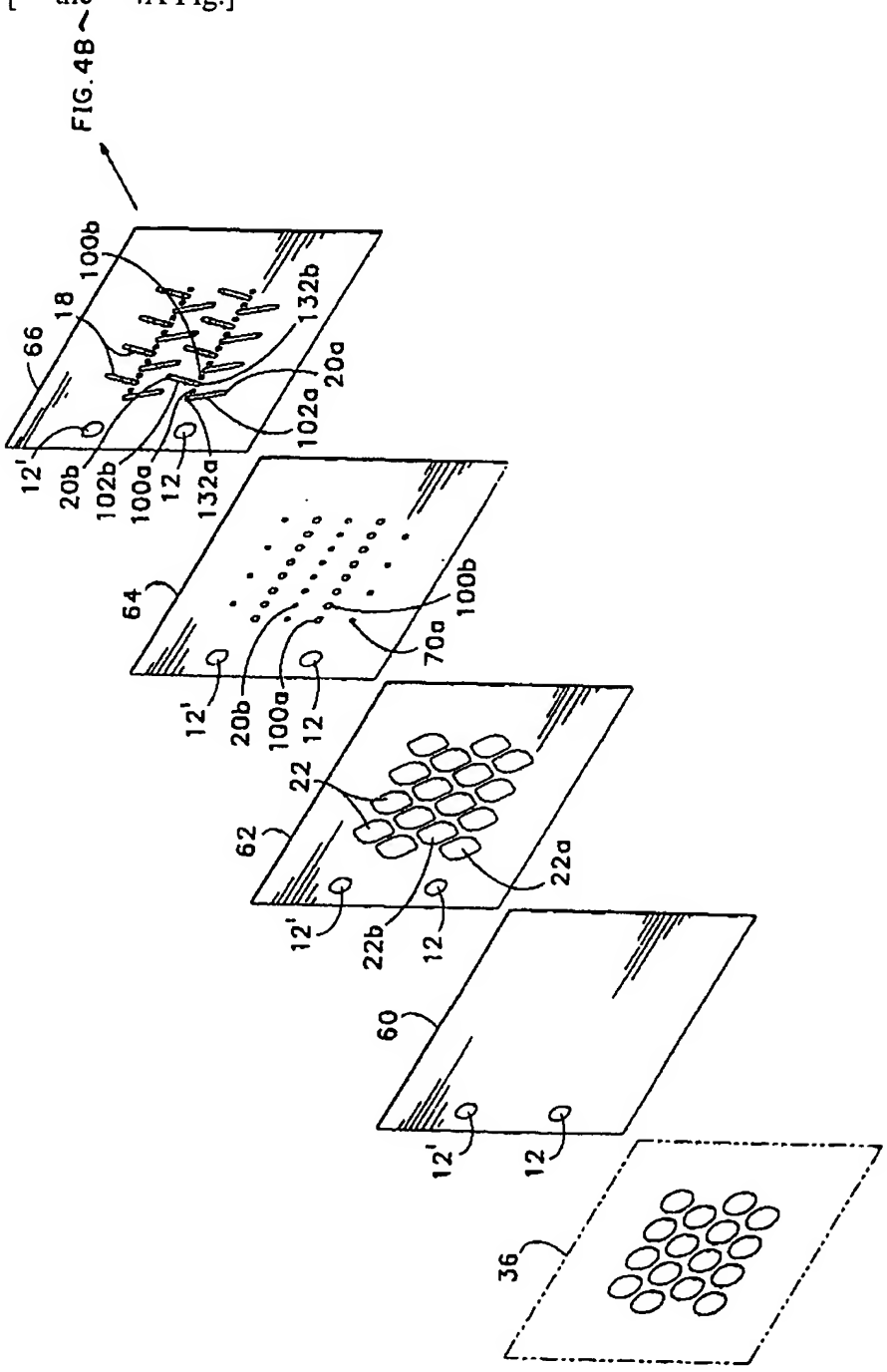
[Fig. 3]


60
62
64
66
68
70
72
42
74
71
76
78
14
20b
22b
100b
100a
22a
132a
20a
102b
102a
46
12

[Fig. 7]


S=C/4
C/8
C/2
L
L
L/2
14
14
71
26
24
22
20
C

[-- the -- 4A Fig.]



[-- the -- 4B Fig.]

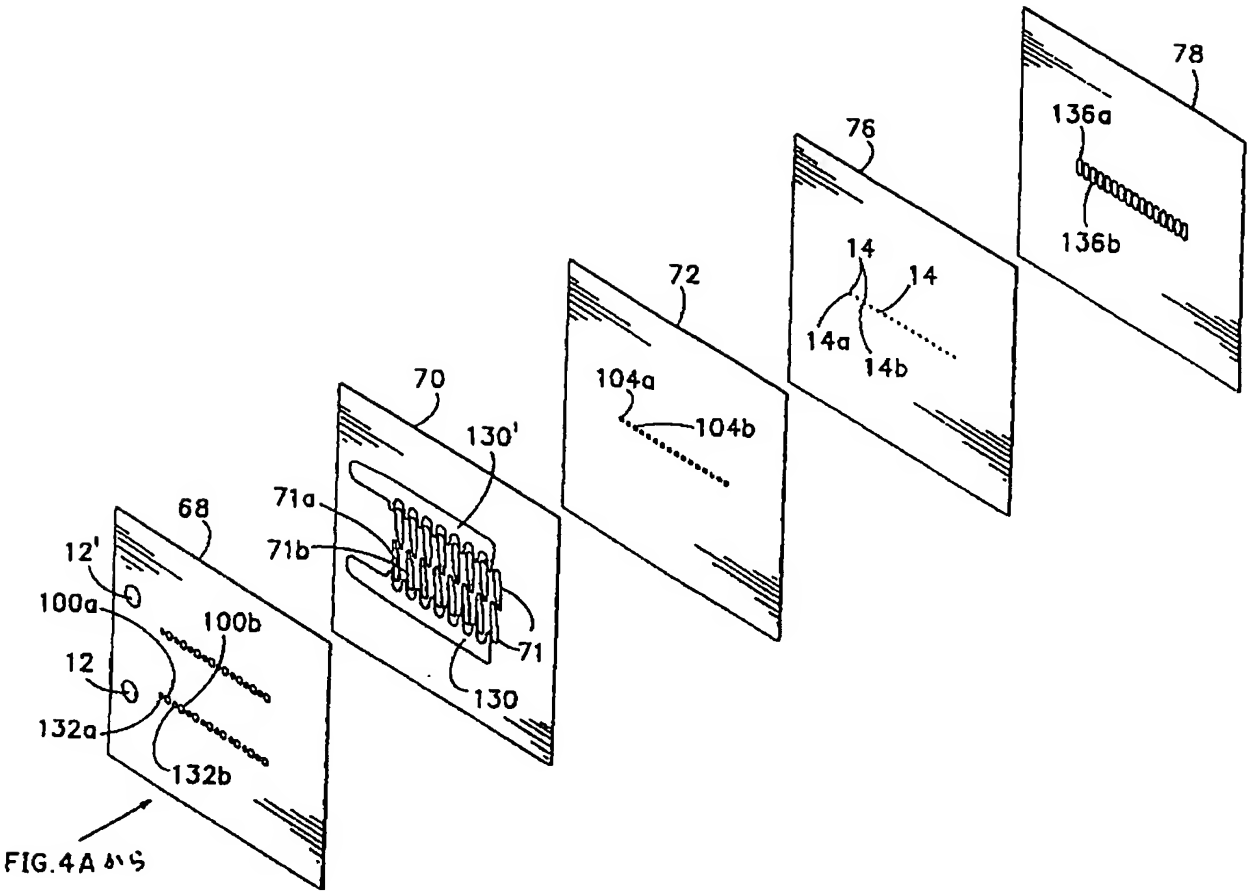
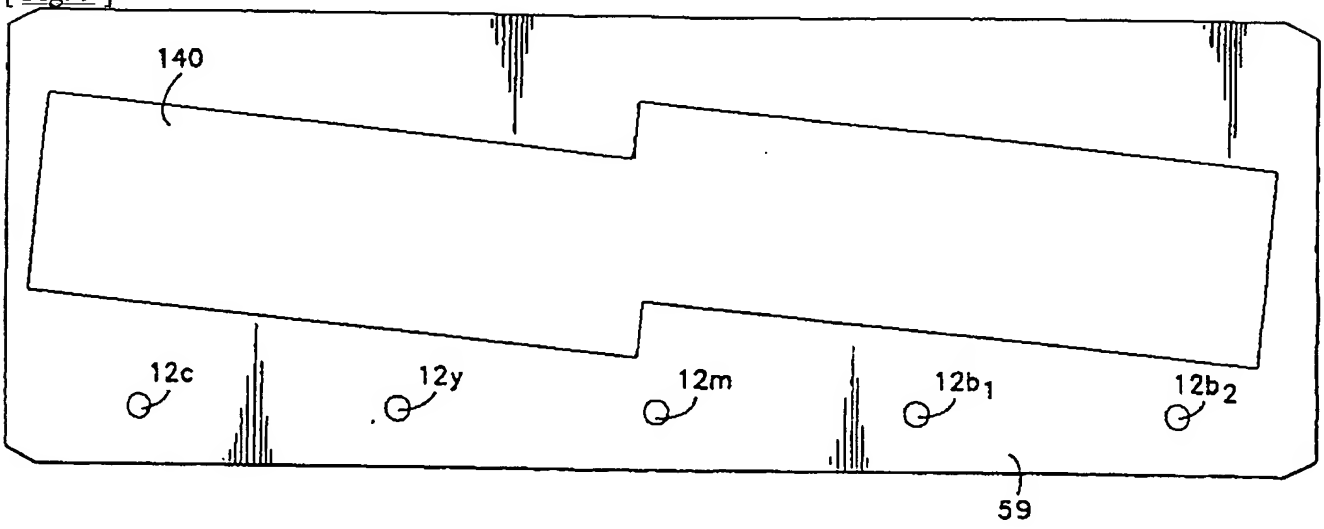
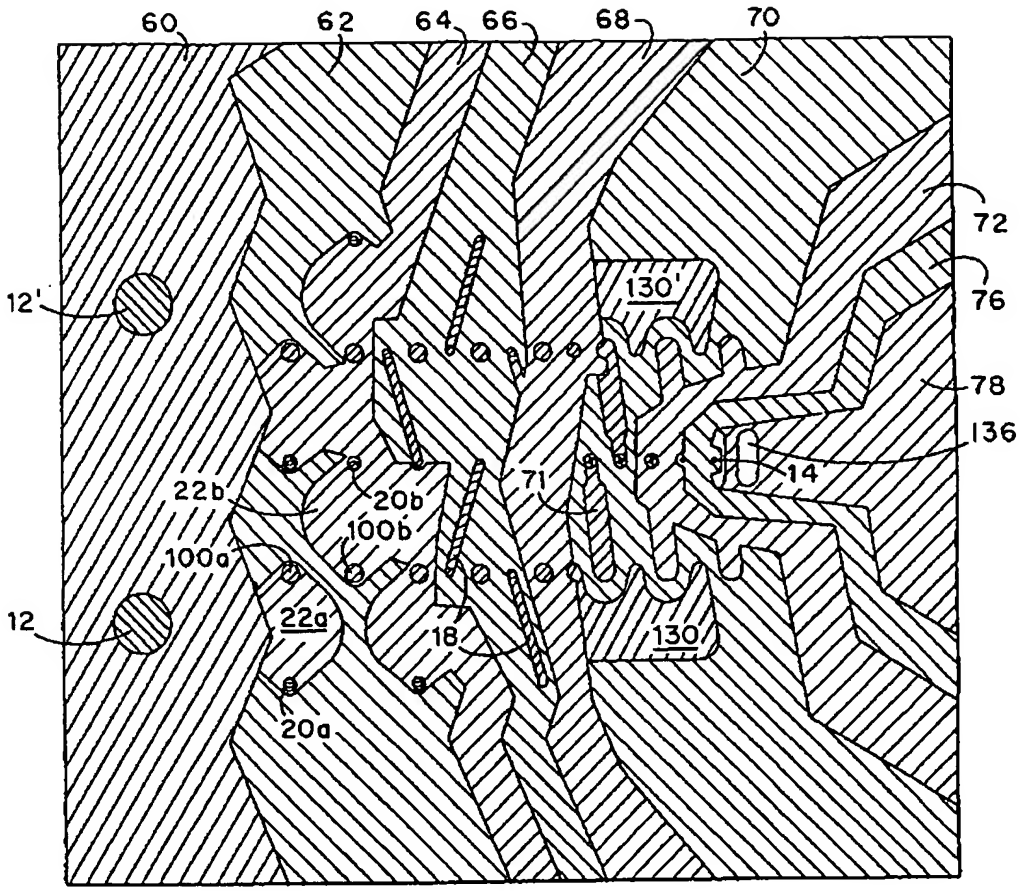


FIG.4A

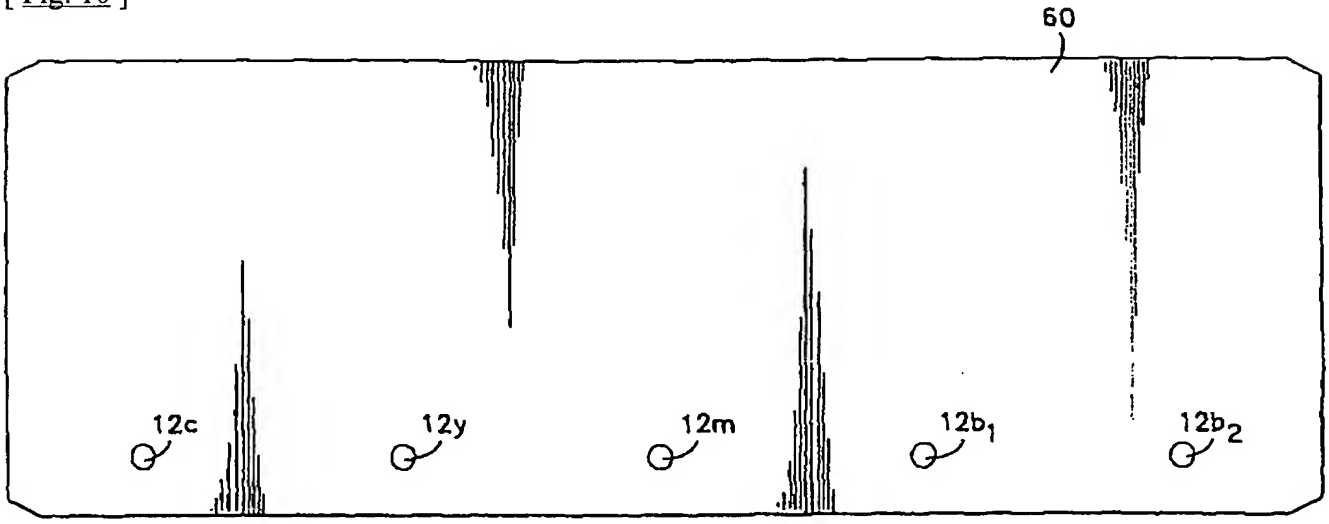
[Fig. 9]



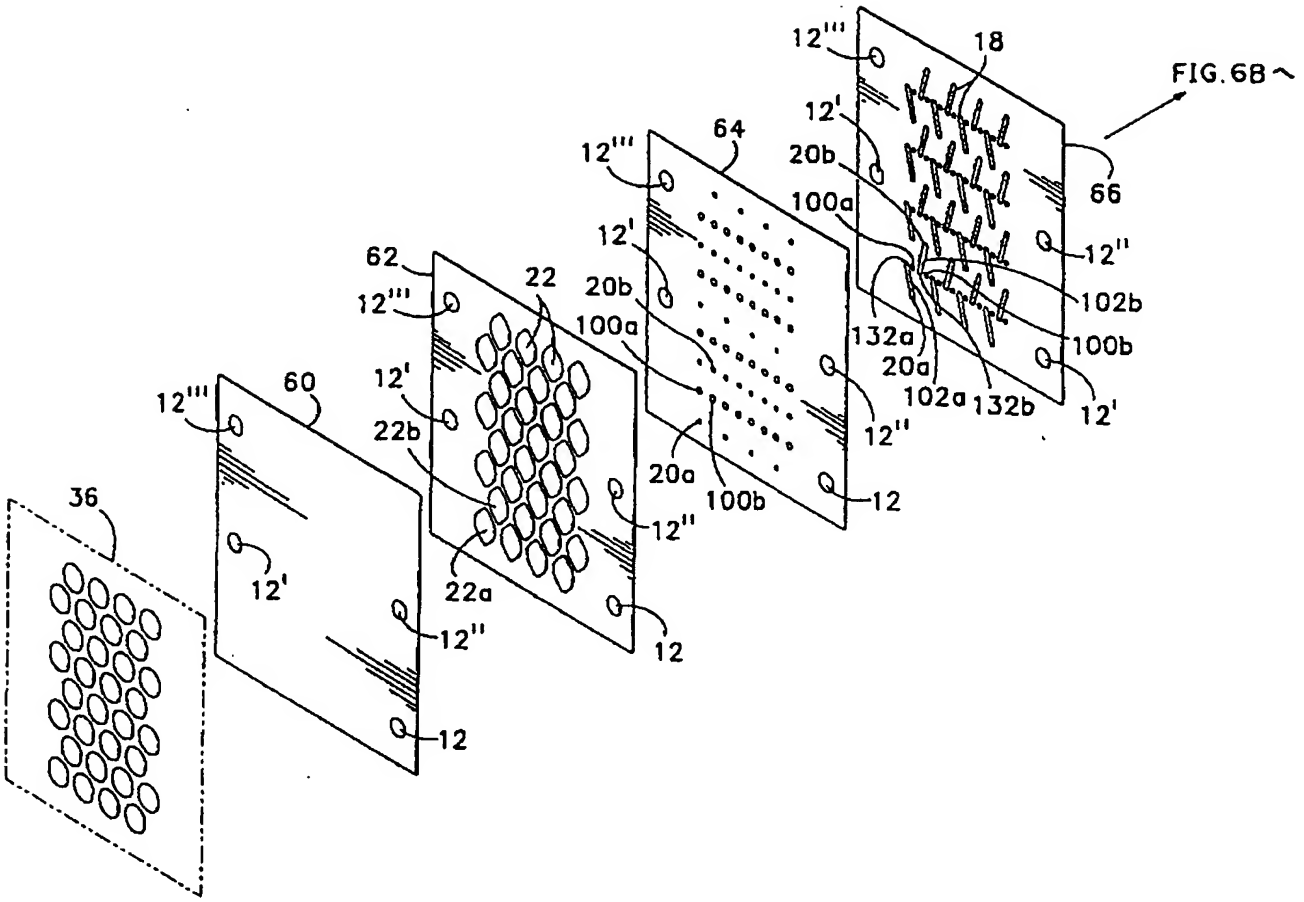
[Fig. 5]



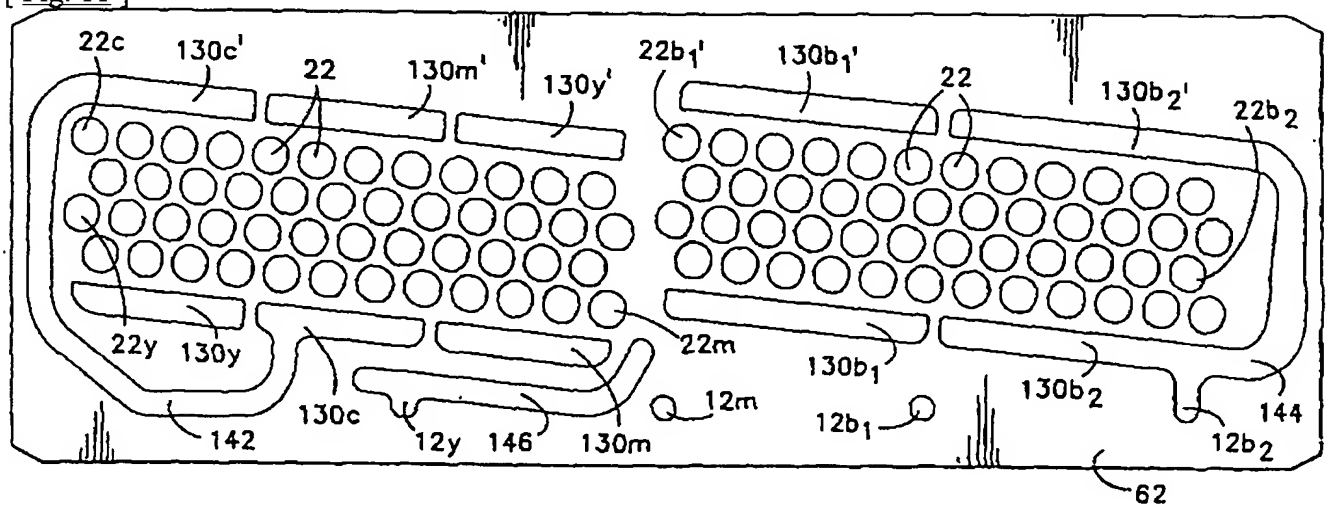
[Fig. 10]



[-- the -- 6A Fig.]



[Fig. 11]



[-- the -- 6B Fig.]

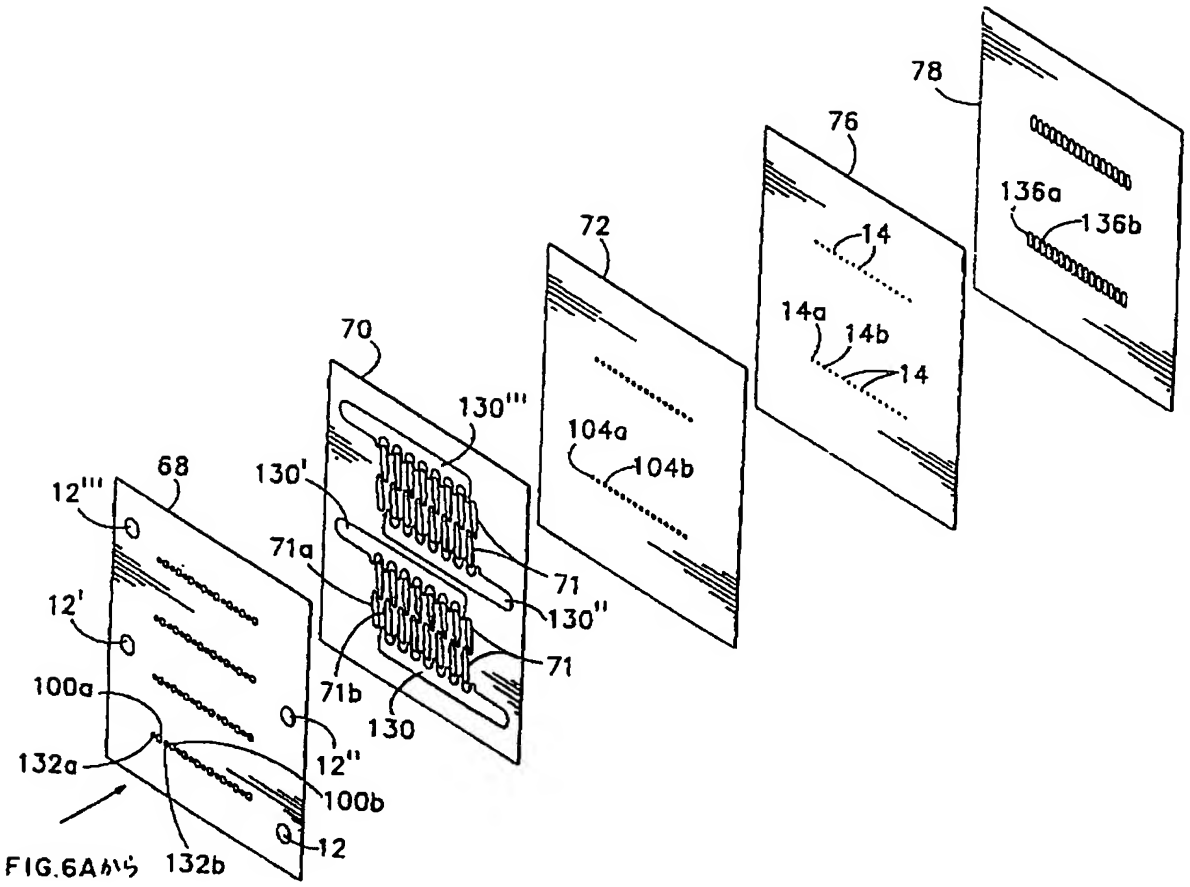
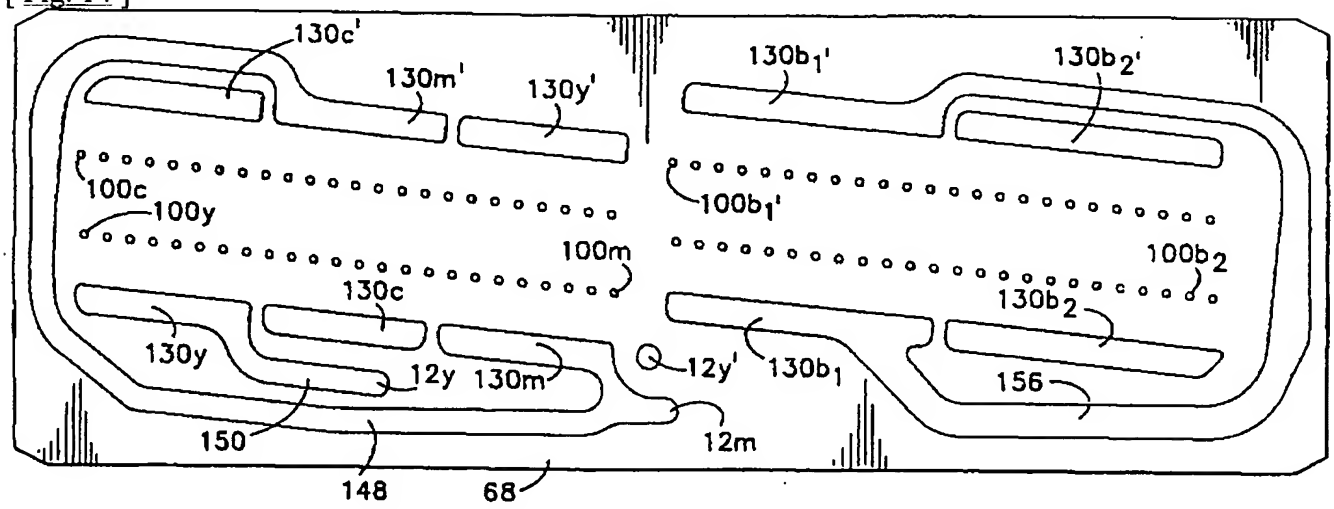
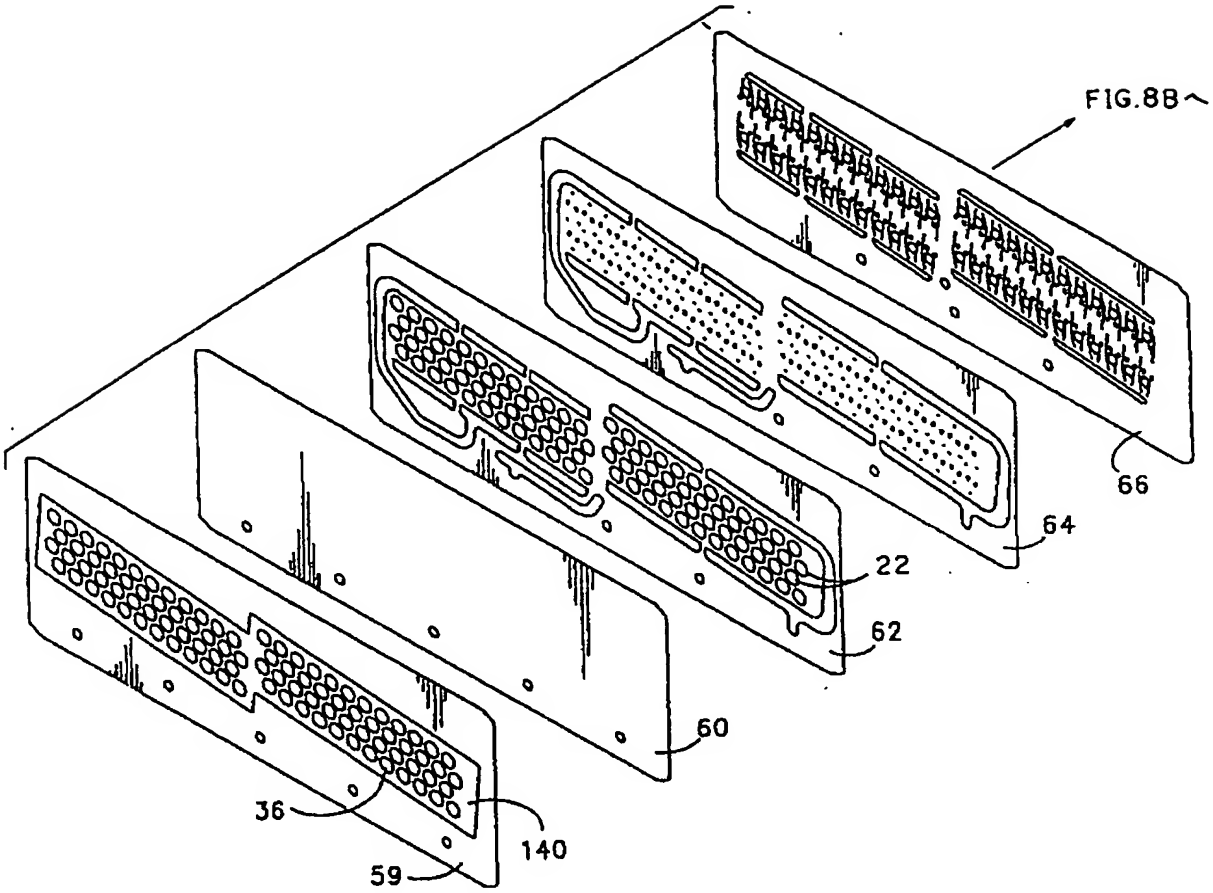


FIG.6Aから

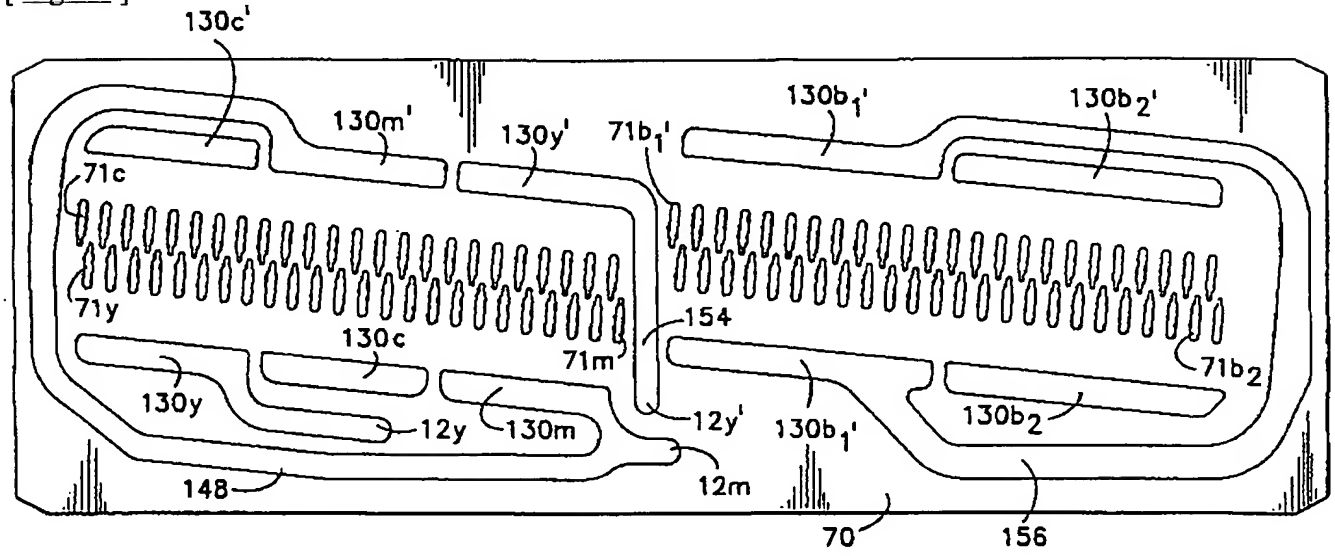
[Fig. 14]



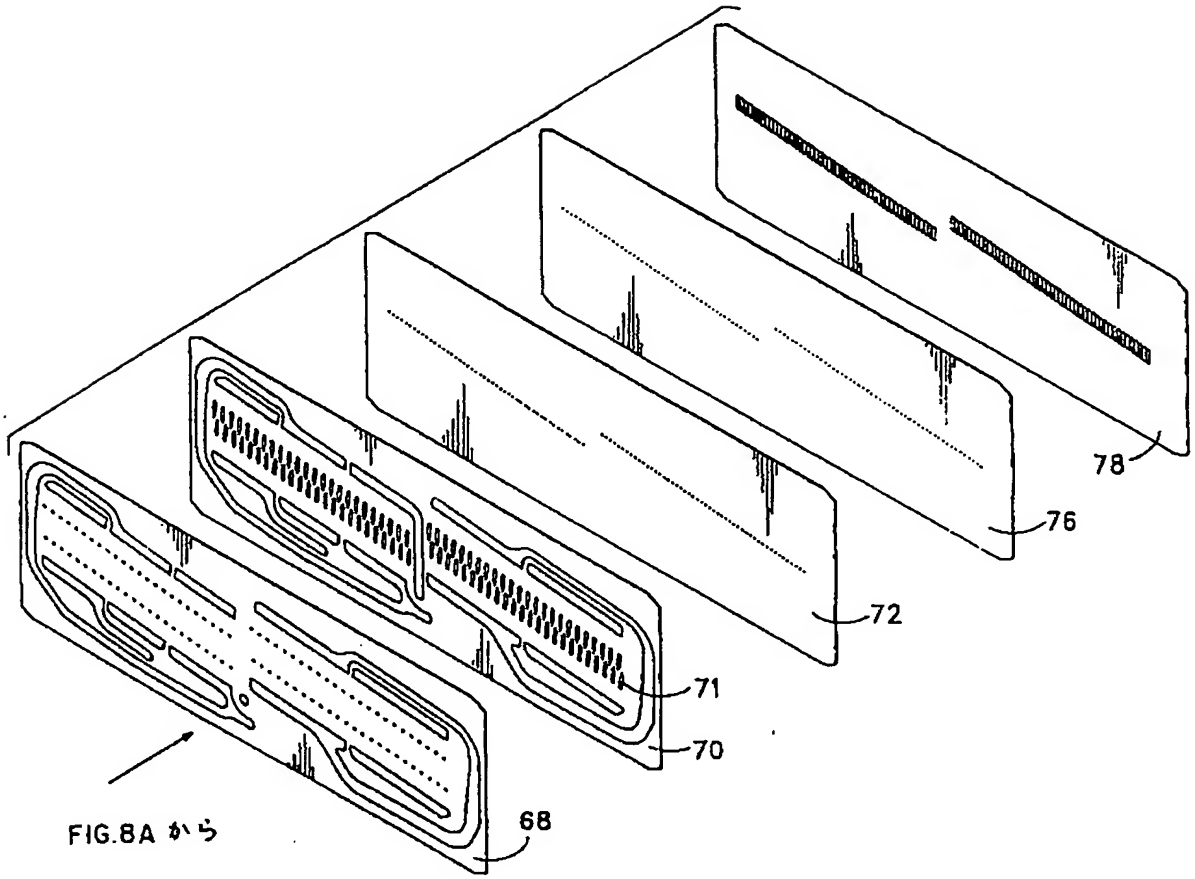
[-- the -- 8A Fig.]



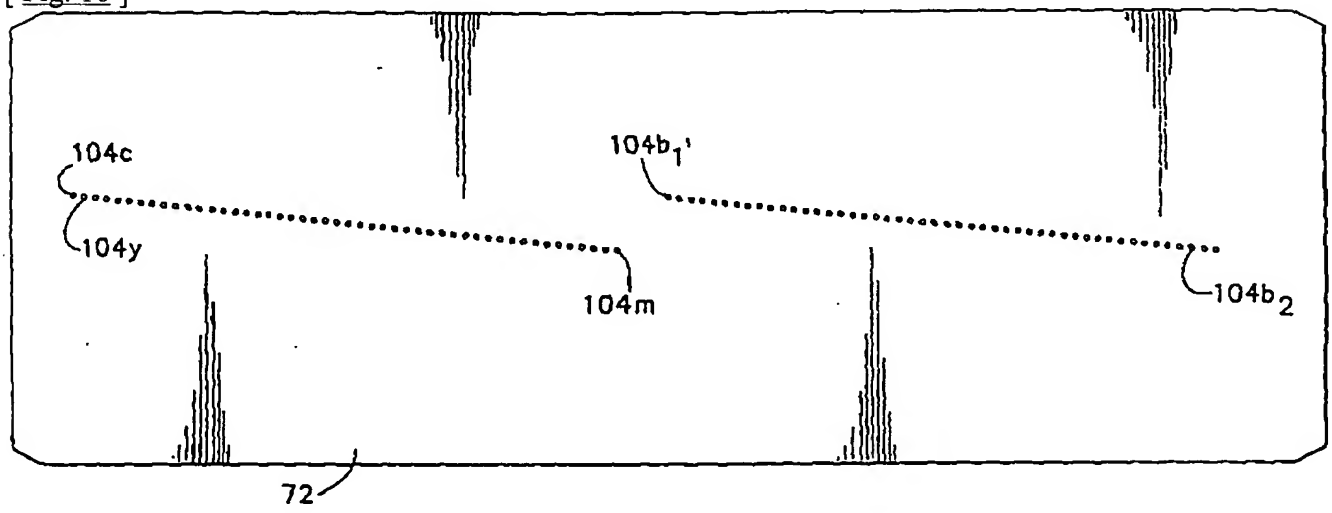
[Fig. 15]



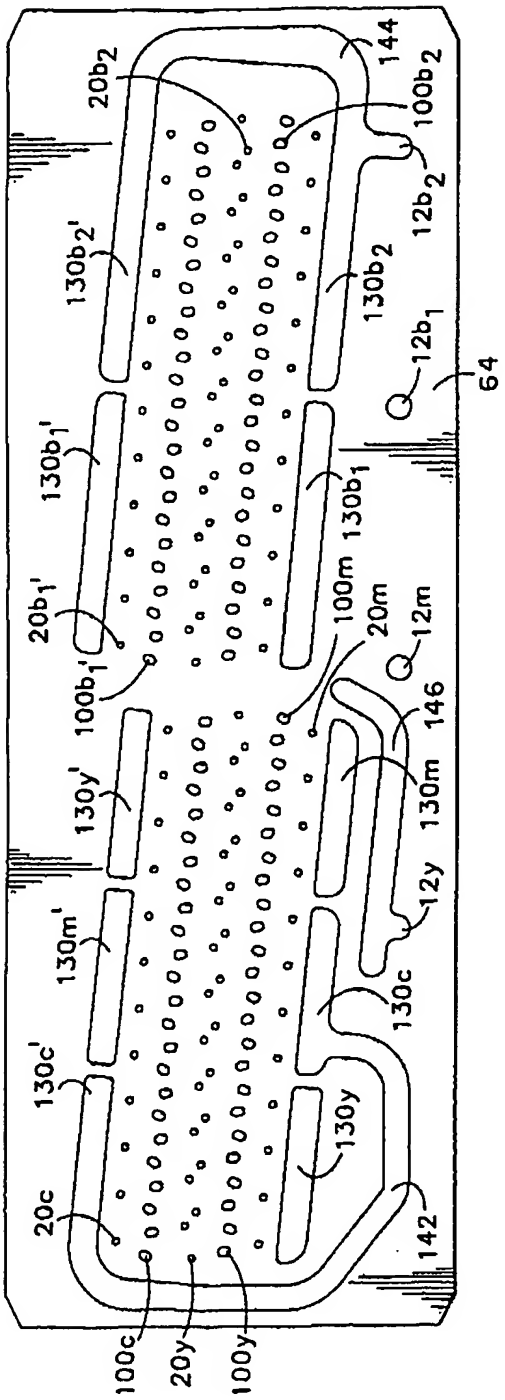
[-- the -- 8B Fig.]



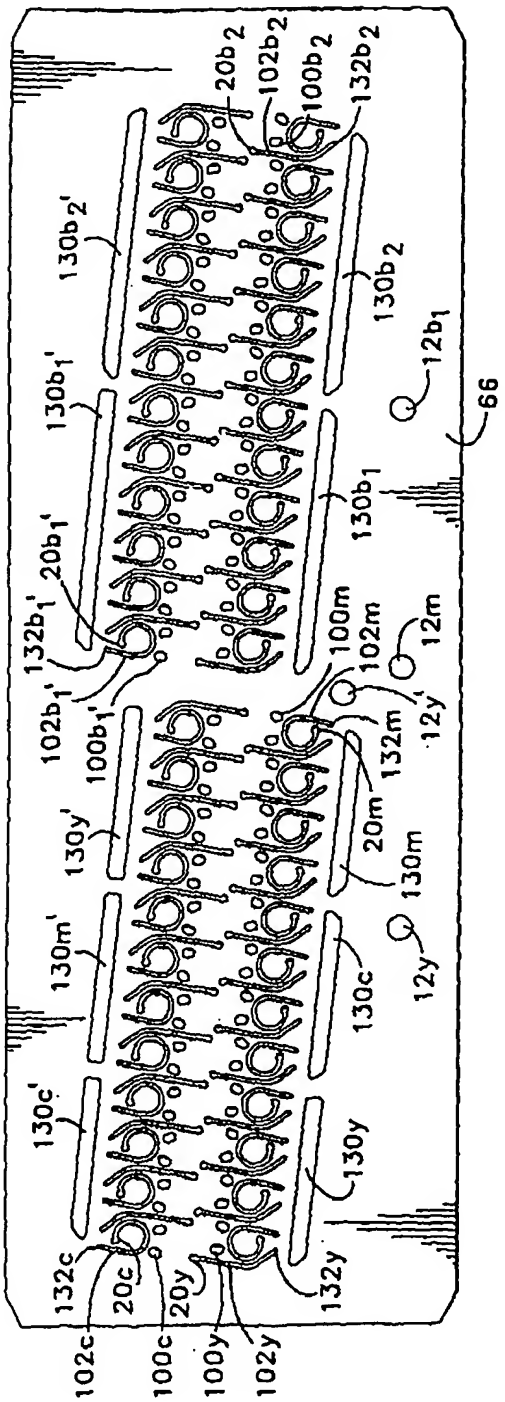
[Fig. 16]



[Fig. 12]


144
20b2
100b2
12b2
130b2'
130b2
12b1
64
130b1'
130b1
20b1'
100m
20m
12m
100b1'
146
130y'
130m
12y
130m'
130c
130c'
130y
20c
142
100c
20y
100y

[Fig. 13]


20b2
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100b2
132b2
130b2'
130b2
12b1
66
130b1'
130b1
20b1'
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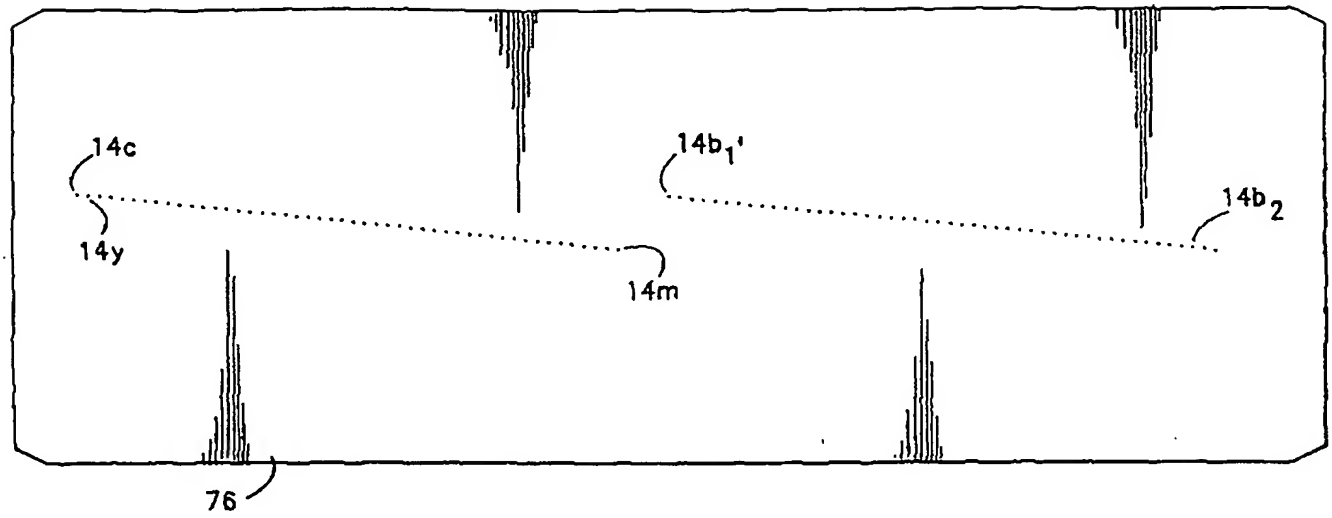
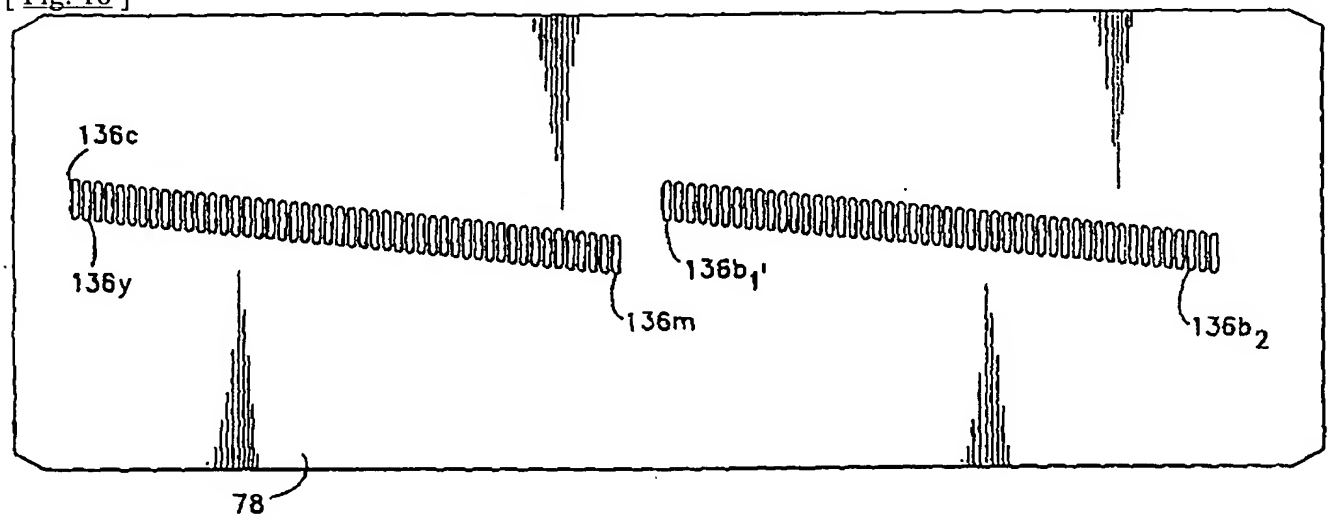
102b1'
100b1'
100m
102m
12m
12y'
132m
20m
130m
130y'
130m'
130c
12y
130c'
130y
132c
20c
20y
132y
102c
100c
100y
102y

[Fig. 17]



[Fig. 18]



[Translation done.]